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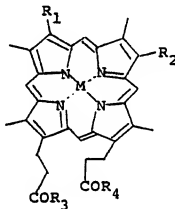
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(84) **Porphyrin derivatives.**

(85) The subject matter of the invention are metalloporphyrin compounds represented by the general formula (I)



wherein

R₁ and R₂ are each -CH=CH₂, -CH(OR)₂ or -CH(O-lower alkylene-OR)₂;

R₃ and R₄ are -OH or a residue obtained by removing a hydrogen atom from a polyfunctional compound;

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R is -H, alkyl, alkenyl, perfluoroalkyl, a cyclic compound, or a residue obtained by removing a hydrogen atom from a polyfunctional compound; and
M is a metal.

The compounds of the invention may be used as a therapeutic or diagnostic agent for malignant tumors, as a tumor marker or as an agent for use in the missile therapy of cancers.

Porphyrin Derivatives

The present invention concerns a novel composition having affinity to cancerous tissues and containing as an effective component metalloporphyrin derivative(s) for use as a tumor marker, and for diagnosis and treatment of cancers.

It is well known in the art that porphyrin derivatives selectively accumulate in cancer tissues. However, this selectivity is not necessarily sufficient. Porphyrin derivatives, on the other hand, manifest toxicity when exposed to light, and patients to which these substances have been administered are required to stay in the dark for an extended period of time before the porphyrin derivatives which have accumulated in their normal tissues are completely discharged out of their body.

It has been found that metalloporphyrins obtained by introducing a certain metal into the porphyrin skeletons (JP-A-81-83185) and porphyrin derivatives having a chelate-forming group (JP-B-63-13997) had their photo-toxicity decreased while retaining affinity to cancer. It was also discovered that amino acid bearing porphyrin derivatives having groups which are labelled by iodine and those which have fluorine (JP-A-64-61481) show similar activities.

When the substance of JP-B-63-13997 was labelled with ^{111}In or $^{99\text{m}}\text{Tc}$, and the substance of JP-A-64-61481 with ^{125}I in order to obtain RI imagings of tumor bearing animals, it was found that the excretion rate of these substances from their liver was quite slow and not necessarily complete, suggesting that these substances are not suitable for diagnosing and treating all kinds of cancers of all the sites.

On the other hand, JP-A-62-5912, 62-5924, 62-5985 and 62-5986 disclose syntheses of various amino acid derivatives of porphyrin, use of monoamino acid derivatives of chlorin in photodiagnosis of cancers using a laser fluorescence endoscopy analyser, and cancer treatment with laser. However, said compounds are not metalloporphyrin derivatives, and were developed solely for diagnosis and therapy with laser irradiation. In its table of efficacies, there are noted side effects such as swelling of the legs and damages to the muscles, thus indicating considerable toxicity of said compounds. Use of a metalloporphyrin derivative in diagnosing and treatment of cancer with laser is reported using protoporphyrin Sn and Mg complexes (JP-A-63-264524). These metalloprotoporphyrin derivatives do not accumulate in cancer tissues selectively.

Paramagnetic metals such as Mn and Fe are used as the contrast medium for magnetic resonance imaging (MRI). Philip et al synthesized Mn-tetraphenyl porphine trisulfonate (Mn-TPPS) for use in MRI (Cancer Research 48, 4604 (1988)). This TPPS derivative demonstrates a potent toxicity and lacks selectivity for cancer tissues, and is therefore not fit for practical use.

Sodium Hg-hematoporphyrin and protoporphyrin Co complex were developed and officially registered as pharmaceuticals as the porphyrin compounds with anti-tumor effects. However, the former was judged as "without cause to determine its efficacy" in 1960 and the latter in 1982, and their manufacture and sale were respectively suspended.

As discussed in the foregoing, selectivity and accumulation of a metalloporphyrin compound obtained by introducing a certain metal into the porphyrin skeleton, of a porphyrin derivative having a chelate forming group, and of a tyrosine bearing porphyrin derivative (group labelled by iodine) are not optimal, and therefore diagnosis and treatment of different cancers on all sites are not always possible. There are currently no porphyrin compounds which have a cell killing effect on their own. A need was therefore felt for a metalloporphyrin derivative which demonstrates potent cancer cell destroying effects on its own, or when used with an external energy such as laser, and a metalloporphyrin derivative useful for MRI which is more potent than the prior substances.

There are porphyrin derivatives which are susceptible to photosensitization and others which are not. The former are inherently defective in that phototoxicity appears, but are useful in therapies such as photodynamic therapy (PDT) and that which uses an external energy. On the other hand, the latter are useful as an agent for diagnosing and treating cancer because they do not induce phototoxicity.

It is the object of the invention to provide novel substances with affinity to cancer cells which show the desired characteristics for use in treatment and diagnosis of cancer, as a tumor marker and in the missile therapy of cancer.

This object was solved on the basis of the elucidation of physicochemical characteristics of the cell necrosis effect which porphyrin derivatives demonstrate at photoradiation. There are two stages of destruction; Mechanism I under which the pigments are excited by light to assume the triple state which directly destroys the cancer cells, and Mechanism II under which the pigments in the triple state further excite oxygen to form the singlet state oxygen (activated oxygen) leading to cell necrosis. In the case of porphyrin derivatives, the Mechanism II is considered prevalent. By measuring the triple state life time (the

fluorescence and phosphorescence life time) which indicates porphyrin's triple state, the length of phosphorescence life time is compared to reveal the intensity of photo-sensitivity. Table 1 shows luminescence properties of various porphyrin derivatives, and indicates that phosphorescence life time is largely affected by the coordination metals of metalloporphyrin derivatives. In other words, phosphorescence life time of metalloporphyrins coordinated with such metals as Zn and Ga is long while that of those coordinated with Mn, Fe, or Cu is very short.

Having considered the above, it was decided to develop metalloporphyrin derivatives with long phosphorescence life time (Ga and Zn complexes) as a drug for treating cancer which uses PDT or an external energy, and those with short phosphorescence life time (Mn, Fe and Cu complexes) as a diagnostic drug for cancer in MRI and RI, and as an antitumor agent on its own. Having conducted further researches on uses of porphyrin derivatives by noting both characteristics (both long and short phosphorescence life time), it was found that if at least one polyfunctional compound was bonded to the side chain of the metalloporphyrin compound, said porphyrin compound with above mentioned properties would be quickly excreted from the normal tissues while maintaining affinity to cancer.

Table 1

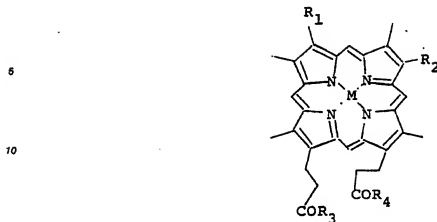
Compounds	Absorbance (nm)	Fluorescence (nm)	Phosphorescence (nm)	Phosphorescence life time (ms)	
				Filter paper	Solution
PP-Me	633	635	/	1.8	/
Mg-PP-Me	590	600	-	-	-
Mn-PP-Me	570	575	710	20 μ s	20 μ s
Fe-PP-Me	645	-	-	-	-
Co-PP-Me	570	-	-	-	-
Cu-PP-Me	572	-	705	20 μ s	100 μ s
Zn-PP-Me	582	588	715	35	/
Ga-PP-Me	570	575	715	50	200
In-PP-Me	583	590	730	7.6	14.1
Sn-PP-Me	583	590	735	7.6	13
Me-PPB	670	675	/	1.7	/
Photofrin-II	620	625	735	9	/

PP: protoporphyrin, PPB: pheophorbide

The properties of the present invention porphyrin derivatives do not undergo any substantial change even when bonded to other active substances or combined with external energy.

The subject matter of the present invention are metalloporphyrin compounds expressed by the formula

(I)



(wherein

R_1 and R_2 are each $-\text{CH}=\text{CH}_2$, $-\text{CH}(\text{OR})\text{CH}_3$ or $-\text{CH}(\text{O-lower alkylene-OR})\text{CH}_3$;

R_3 and R_4 are $-\text{OH}$ or a residue obtained by removing a hydrogen atom from a polyfunctional compound;

R is $-\text{H}$, alkyl, alkenyl, perfluoroalkyl, a cyclic compound, or a residue obtained by removing a hydroxy group from a polyfunctional compound; and

M is a metal).

In the above definitions of the symbols, the term "lower alkylene" means alkylene having usually less than 5 carbon atoms, preferably from 1 to 3 carbon atoms (e.g. ethylene, trimethylene, and propylene), while the term "alkyl" means alkyl having usually less than 20 carbon atoms, preferably from 1 to 18 carbon atoms (e.g. methyl, ethyl, n-propyl, hexyl, octyl, decyl, dihydrocitraonellyl, undecyl, dodecyl, tetradecyl, and octadecyl), and the term "alkenyl" means alkenyl having less than 20 carbon atoms, preferably from 6 to 18 carbon atoms (e.g. hexenyl, octenyl, geranyl, cytronellyl, and octadecenyl).

The term "perfluoroalkyl" means perfluoroalkyl having less than 20 carbon atoms, preferably from 2 to 11 carbon atoms (e.g. hexafluorobutyl, octafluoropentyl, dodecafluoroheptyl, and pentadecafluorooctyl) and the term "cyclic compound" means cyclic compounds having less than 7 membered rings (e.g. cyclohexyl and menthyl).

The term "polyfunctional compound" means those having at least 2 functional groups (e.g. $-\text{NH}_2$, $-\text{OH}$, $-\text{O}-$, $-\text{SH}$, $-\text{S}-$, $-\text{COOH}$, and halogen) and, preferably, amino acids (e.g. glycine, cysteine, glutamic acid, alanine, cystine, aspartic acid, asparagine, valine, methionine, glutamine, leucine, phenylalanine, isoleucine, serine, tryptophane, threonine, histidine, lysine, and tyrosine), polyamines (e.g. ethylenediamine, hexamethylenediamine, hydrazine, and tetraethylene pentamine), polyhydric alcohols (e.g. ethylene glycol, methyl cellosolve, ethyl cellosolve, and carbitol), heterocyclic alcohols (e.g. tetrahydrofurfuryl alcohol, tetrahydropyran-2-methanol, and 3-pyridine-methanol), amino alcohols (e.g. monoethanolamine, dimethylamino ethanol, hydroxylamine, and hydralino-ethanol), sulfur containing alcohols (e.g. methionol), halogen alcohols (e.g. monobromoethanol and trichloro alcohol), phenethyl alcohol, taurine and hydroxy acetic acid.

Some of these substances are optically active, and levo-rotatory compound, dextro-rotatory compound or DL-rotatory compound may be used or that which has converted to DL-rotatory compound during photosynthesis may be used. They may also be used in the form of salt of alkali metal.

The metalloporphyrin compounds (I) according to the present invention are novel substances, but the compounds per se can be prepared routinely. The process of preparation usually follows the step (a), wherein the porphyrin compound of the formula (I) having R_1 and R_2 is obtained, the step (b) wherein a metal is introduced therein, and the step (c) wherein thus obtained metalloporphyrin compound is bonded at R_3 and R_4 with a residue of a polyfunctional compound (e.g. amino acid). It is not necessarily important to sequentially conduct the reactions in the order of (a), (b) and (c). The order may be varied as (b), (a) and (c), or (a), (c) and (b).

The steps (a) and (b) can be performed by a routine method such as that disclosed in J. E. Falk: Porphyrins and Metalloporphyrins (Elsevier, 1975). A metalloporphyrin compound having R_1 and R_2 corresponding to the formula (I) may be prepared according to the methods disclosed in JP-A-61-7279, JP-A-61-83185, and JP-B-63-13997. For the step (a), it is sufficient to introduce R to R_1 and R_2 side chains of the porphyrin compound (I), and the polyfunctional compound may be reacted in respect of its hydroxyl group, or with other functional groups (such as $-\text{NH}_2$ group). If the polyfunctional compound having a

hydroxyl group is to be used, it is preferable to prepare Br derivatives of the porphyrin compound (I) in advance, and to continue reactions with the hydroxyl group of a polyfunctional compound. Other functional groups of the polyfunctional compound therefore may be protected suitably. For the step (b), a metal chloride, acetate, sulfate or nitrate, is usually used. As metals, Mg, Si, Ti, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge and In are used. The step of metal introduction (b) may be performed before or after the step (a) depending on the need. For instance, the step (b) may be performed first, Br derivatives of metalloporphyrin prepared, and then Br derivative reacted with the functional compound (the step (a)). Instead of artificial synthesis, this compound may be obtained from a natural source such as a plant or an animal.

The thus obtained metalloporphyrin compound is then subjected to the step (c) where it is bonded to the residue of a polyfunctional compound. By reacting a metalloporphyrin compound (I) at least either R₃ or R₄ of which is -OH with a polyfunctional compound (mainly amino acid, polyamine, and amino alcohols), a polyfunctional compound-bearing-metalloporphyrin compound (I) is obtained. This may be performed by a routine method discussed in Izumiya et al: Basis and Test on Peptide Synthesis (Maruzen, 1985) (in Japanese) and by following a method disclosed in JP-A-64-61481. Instead of artificial synthesis, this compound may be obtained from a natural source such as a plant or an animal.

In this case, since the residue of a polyfunctional compound is to be merely introduced into the side chain of the porphyrin compound (I), the polyfunctional compound may be reacted in respect of its amino group, or with other functional groups (such as -OH group). For instance, if a polyfunctional compound having an amino group is to be used, it is preferable to proceed with the reaction between a carboxyl group at R₃ and R₄ side chains of the porphyrin compound (I) and an amino group of a polyfunctional compound. Therefore, it is preferable to convert the former carboxyl group and/or the latter amino group to routine reacting groups, or to suitably protect groups which should not participate in the reaction between the two. In either case, reaction-promoting agents such as a dehydrating agent and a deoxidizer or condensing agents may be used.

The process of preparing metalloporphyrin compound (I) is now explained concretely by referring to representative examples. If the polyfunctional compound has an amino group, a metalloporphyrin compound at least either R₃ or R₄ of which is an OH group (JP-A-61-7279, JP-A-61-83185, and JP-B-63-13997) is reacted with the amino group-bearing polyfunctional compound (e.g. amino acid methyl ester) in a solvent using a condensing agent (e.g. dicyclohexylcarbodiimide (DCC) or water soluble carbodiimide (WSC)), and a metalloporphyrin compound (I) having at least one amino group-bearing polyfunctional compound at R₃ and R₄ side chains is obtained. Their concrete examples, and examples of the metalloporphyrin compounds (I) thus produced are discussed below.

- (1) Ga-protoporphyrinyl monoglycine (hereinafter referred to as Ga-PP-monoGly);
- (2) Ga-protoporphyrinyl diaspartic acid (hereinafter referred to as Ga-PP-diAsp);
- (3) Ga-protoporphyrinyl dityrosine (hereinafter referred to as Ga-PP-diTyr);
- (4) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl monoglycine (hereinafter referred to as monoEG-Ga-DP-monoGly);
- (5) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as monoEG-Ga-DP-diGly);
- (6) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl dileucine (hereinafter referred to as monoEG-Ga-DP-diLeu);
- (7) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl monoaspartic acid (hereinafter referred to as monoEG-Ga-DP-monoAsp);
- (8) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as monoEG-Ga-DP-diAsp);
- (9) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl monophenylalanine (hereinafter referred to as monoEG-Ga-DP-monoPhe);
- (10) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl diphenylalanine (hereinafter referred to as monoEG-Ga-DP-diPhe);
- (11) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl monotyrosine (hereinafter referred to as monoEG-Ga-DP-monoTyr);
- (12) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Ga-deuteroporphyrinyl dityrosine (hereinafter referred to as monoEG-Ga-DP-diTyr);
- (13) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyrinyl monoglycine (hereinafter referred to as EG-Ga-DP-monoGly);
- (14) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as EG-Ga-DP-diGly);
- (15) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyrinyl monoleucine (hereinafter referred to as

- EG-Ga-DP-monoLeu);
 (16) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl dlleucine (hereinafter referred to as EG-Ga-DP-dlLeu);
 (17) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoisoleucine (hereinafter referred to as EG-Ga-DP-monoIle);
 (18) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl dlisoleucine (hereinafter referred to as EG-Ga-DP-dlIle);
 (19) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoserine (hereinafter referred to as EG-Ga-DP-monoSer);
 (20) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monocysteine (hereinafter referred to as EG-Ga-DP-monoCys);
 (21) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monomethionine (hereinafter referred to as EG-Ga-DP-monoMet);
 (22) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoaspartic acid (hereinafter referred to as EG-Ga-DP-monoAsp);
 (23) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl mono[D]aspartic acid (hereinafter referred to as EG-Ga-DP-Mono[D]Asp);
 (24) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl diaspartic acid (hereinafter referred to as EG-Ga-DP-dlAsp);
 (25) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoasparagine (hereinafter referred to as EG-Ga-DP-monoAsn);
 (26) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoglutamic acid (hereinafter referred to as EG-Ga-DP-monoGlu);
 (27) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl diglutamic acid (hereinafter referred to as EG-Ga-DP-dlGlu);
 (28) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monolysine (hereinafter referred to as EG-Ga-DP-monoLys);
 (29) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monophenylalanine (hereinafter referred to as EG-Ga-DP-monoPhe);
 (30) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl diphenylalanine (hereinafter referred to as EG-Ga-DP-dlPhe);
 (31) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monotyrosine (hereinafter referred to as EG-Ga-DP-monoTyr);
 (32) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl dityrosine (hereinafter referred to as EG-Ga-DP-dlTyr);
 (33) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl glycine*aspartic acid (hereinafter referred to as EG-Ga-DP-Gly*Asp);
 (34) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl serine*aspartic acid (hereinafter referred to as EG-Ga-DP-Ser*Asp);
 (35) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl aspartic acid*phenylalanine (hereinafter referred to as EG-Ga-DP-Asp*Phe);
 (36) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl aspartic acid*tyrosine (hereinafter referred to as EG-Ga-DP-Asp*Tyr);
 (37) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyryl monoserine (hereinafter referred to as MC-Ga-DP-monoSer);
 (38) 2,4-bis[1-(2-methoxyethyloxy)ethyl]-Ga-deuteroporphyryl monoaspartic acid (hereinafter referred to as MC-Ga-DP-monoAsp);
 (39) 2,4-bis[1-(2-methoxyethyloxy)ethyl]-Ga-deuteroporphyryl diaspartic acid (hereinafter referred to as MC-Ga-DP-dlAsp);
 (40) 2,4-bis[1-(2-ethoxyethyloxy)ethyl]-Ga-deuteroporphyryl monoaspartic acid (hereinafter referred to as EC-Ga-DP-monoAsp);
 (41) 2,4-bis[1-(2-ethoxyethyloxy)ethyl]-Ga-deuteroporphyryl diaspartic acid (hereinafter referred to as EC-Ga-DP-dlAsp);
 (42) 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyryl monoserine (hereinafter referred to as C₁-Ga-DP-monoSer);
 (43) 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyryl monoaspartic acid (hereinafter referred to as C₁-Ga-DP-monoAsp);
 (44) 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyryl diaspartic acid (hereinafter referred to as C₁-Ga-

- DP-diAsp);
- (45) 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyrinyl monotyrosine (hereinafter referred to as C₁-Ga-DP-monoTyr);
- (46) 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyrinyl dityrosine (hereinafter referred to as C₁-Ga-DP-diTyr);
- (47) 2,4-bis(1-ethoxyethyl)-Ga-deuteroporphyrinyl monoaspartic acid (hereinafter referred to as C₂-Ga-DP-monoAsp);
- (48) 2,4-bis(1-ethoxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₂-Ga-DP-diAsp);
- (49) 2,4-bis(1-propoxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₃-Ga-DP-diAsp);
- (50) 2,4-bis(1-isopropoxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{3(iso)}-Ga-DP-diAsp);
- (51) 2,4-bis(1-butoxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₄-Ga-DP-diAsp);
- (52) 2,4-bis(1-pentyloxyethyl)-Ga-deuteroporphyrinyl diserine (hereinafter referred to as C₅-Ga-DP-diSer);
- (53) 2,4-bis(1-pentyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₅-Ga-DP-diAsp);
- (54) 2,4-bis(1-hexyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₆-Ga-DP-diAsp);
- (55) 2,4-bis(1-heptyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₇-Ga-DP-diAsp);
- (56) 2,4-bis(1-octyloxyethyl)-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as C₈-Ga-DP-diGly);
- (57) 2,4-bis(1-octyloxyethyl)-Ga-deuteroporphyrinyl diserine (hereinafter referred to as C₈-Ga-DP-diSer);
- (58) 2,4-bis(1-octyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₈-Ga-DP-diAsp);
- (59) 2,4-bis(1-octyloxyethyl)-Ga-deuteroporphyrinyl dityrosine (hereinafter referred to as C₈-Ga-DP-diTyr);
- (60) 2-(1-octyloxyethyl)-4-ethenyl-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as C_{8(mono)}-Ga-DP-diGly);
- (61) 2-(1-octyloxyethyl)-4-ethenyl-Ga-deuteroporphyrinyl diserine (hereinafter referred to as C_{8(mono)}-Ga-DP-diSer);
- (62) 2-(1-octyloxyethyl)-4-ethenyl-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{8(mono)}-Ga-DP-diAsp);
- (63) 2-(1-octyloxyethyl)-4-ethenyl-Ga-deuteroporphyrinyl dityrosine (hereinafter referred to as C_{8(mono)}-Ga-DP-diTyr);
- (64) 2,4-bis(1-phenethyloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as C_{8(Phenethyl)}-Ga-DP);
- (65) 2,4-bis(1-phenethyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{8(Phenethyl)}-Ga-DP-diAsp);
- (66) 2,4-bis(1-nonyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₉-Ga-DP-diAsp);
- (67) 2,4-bis(1-decyloxyethyl)-Ga-deuteroporphyrinyl diserine (hereinafter referred to as C₁₀-Ga-DP-diSer);
- (68) 2,4-bis(1-decyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀-Ga-DP-diAsp);
- (69) 2,4-bis(1-geranyloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as C_{10(gera)}-Ga-DP);
- (70) 2,4-bis(1-geranyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10(gera)}-Ga-DP-diAsp);
- (71) 2,4-bis(1-citronellyloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as C_{10(citro)}-Ga-DP);
- (72) 2,4-bis(1-citronellyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10(citro)}-Ga-DP-diAsp);
- (73) 2,4-bis(1-dihydrocitronellyloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as C_{10+2(citro)}-Ga-DP);
- (74) 2,4-bis(1-dihydrocitronellyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10+2(citro)}-Ga-DP-diAsp);

- (75) 2,4-bis(1-undecyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₁-Ga-DP-diAsp);
- (76) 2,4-bis(1-dodecyloxyethyl)-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as C₁₂-Ga-DP-diGly);
- (77) 2,4-bis(1-dodecyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₂-Ga-DP-diAsp);
- (78) 2,4-bis(1-dodecyloxyethyl)-Ga-deuteroporphyrinyl diglutamic acid (hereinafter referred to as C₁₂-Ga-DP-diGlu);
- (79) 2,4-bis(1-tetrahydrofurfuryloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as H₄Fra-Ga-DP);
- (80) 2,4-bis(1-tetrahydrofurfuryloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as H₄Fra-Ga-DP-diAsp);
- (81) 2,4-bis[1-(tetrahydro-2-pyranmethyloxy)ethyl]-Ga-deuteroporphyrin (hereinafter referred to as H₄Pyran-Ga-DP);
- (82) 2,4-bis[1-(tetrahydro-2-pyranmethyloxy)ethyl]-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as H₄Pyran-Ga-DP-diAsp);
- (83) 2,4-bis(1-nicotinyloxyethyl)-Ga-deuteroporphyrin (hereinafter referred to as Nct-Ga-DP);
- (84) 2,4-bis(1-nicotinyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as Nct-Ga-DP-diAsp);
- (85) 2,4-bis(1-octafluoropentyloxyethyl)-Ga-deuteroporphyrinyl diglycine (hereinafter referred to as C₈(F₁₈)-Ga-DP-diAsp);
- (86) 2,4-bis(1-octafluoropentyloxyethyl)-Ga-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₈(F₁₈)-Ga-DP-diAsp);
- (87) Mg-protoporphyrinyl diaspartic acid (hereinafter referred to as Mg-PP-diAsp);
- (88) Mg-protoporphyrinyl dityrosine (hereinafter referred to as Mg-PP-diTyr);
- (89) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mg-deuteroporphyrin (hereinafter referred to as EG-Mg-DP);
- (90) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mg-deuteroporphyrinyl dityrosine (hereinafter referred to as EG-Mg-DP-diTyr);
- (91) 2,4-bis(1-hexyloxyethyl)-Mg-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₆-Mg-DP-diAsp);
- (92) 2,4-bis(1-octyloxyethyl)-Mg-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₈-Mg-DP-diAsp);
- (93) 2,4-bis(1-decyloxyethyl)-Mg-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀-Mg-DP-diAsp);
- (94) 2,4-bis(1-decyloxyethyl)-Mg-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₂-Mg-DP-diAsp);
- (95) Mn-protoporphyrinyl monotyrosine (hereinafter referred to as Mn-PP-monoTyr);
- (96) Mn-protoporphyrinyl dityrosine (hereinafter referred to as Mn-PP-diTyr);
- (97) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrin (hereinafter referred to as monoEG-Mn-DP);
- (98) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrinyl monoglycine (hereinafter referred to as monoEG-Mn-DP-monoGly);
- (99) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrinyl diglycine (hereinafter referred to as monoEG-Mn-DP-diGly);
- (100) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as monoEG-Mn-DP-diAsp);
- (101) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrinyl diphenylalanine (hereinafter referred to as monoEG-Mn-DP-diPhe);
- (102) 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-Mn-deuteroporphyrinyl dityrosine (hereinafter referred to as monoEG-Mn-DP-diTyr);
- (103) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrin (hereinafter referred to as EG-Mn-DP);
- (104) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monoglycine (hereinafter referred to as EG-Mn-DP-monoGly);
- (105) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglycine (hereinafter referred to as EG-Mn-DP-diGly);
- (106) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monoserine (hereinafter referred to as EG-Mn-DP-monoSer);
- (107) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diserine (hereinafter referred to as

- EG-Mn-DP-diSer);
- (108) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monoaspartic acid (hereinafter referred to as EG-Mn-DP-monoAsp);
- (109) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as EG-Mn-DP-diAsp);
- (110) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monophenylalanine (hereinafter referred to as EG-Mn-DP-monoPhe);
- (111) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diphenylalanine (hereinafter referred to as EG-Mn-DP-diPhe);
- (112) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monotyrosine (hereinafter referred to as EG-Mn-DP-monoTyr);
- (113) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl dityrosine (hereinafter referred to as EG-Mn-DP-diTyr);
- (114) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₉-Mn-DP-diAsp);
- (115) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglycine (hereinafter referred to as C₈-Mn-DP-diGly);
- (116) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₈-Mn-DP-diAsp);
- (117) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglycine (hereinafter referred to as C₁₀-Mn-DP-diGly);
- (118) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl dialanine (hereinafter referred to as C₁₀-Mn-DP-diAla);
- (119) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl dileucine (hereinafter referred to as C₁₀-Mn-DP-diLeu);
- (120) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diserine (hereinafter referred to as C₁₀-Mn-DP-diSer);
- (121) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl dicysteine (hereinafter referred to as C₁₀-Mn-DP-diCys);
- (122) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀-Mn-DP-diAsp);
- (123) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl di[D]aspartic acid (hereinafter referred to as C₁₀-Mn-DP-di[D]Asp);
- (124) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglutamic acid (hereinafter referred to as C₁₀-Mn-DP-diGlu);
- (125) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diphenylalanine (hereinafter referred to as C₁₀-Mn-DP-diPhe);
- (126) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglycidiaspartic acid (hereinafter referred to as C₁₀-Mn-DP-diGly-diAsp);
- (127) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diglycidiaspartic acid (hereinafter referred to as C₁₀-Mn-DP-diLeu-diAsp);
- (128) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diphenylalanyldiaspartic acid (hereinafter referred to as C₁₀-Mn-DP-diPhe-diAsp);
- (129) 2-(1-(2-hydroxyethyloxy)ethyl)-4-ethenyl-Mn-deuteroporphyrinyl dileucine (hereinafter referred to as C₁₀-Mn-DP-diLeu);
- (130) 2-(1-(2-hydroxyethyloxy)ethyl)-4-ethenyl-Mn-deuteroporphyrinyl diglutamic acid (hereinafter referred to as C₁₀(Mn)-Mn-DP-diGlu);
- (131) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl (hereinafter referred to as C₁₀(Mn)-Mn-DP);
- (132) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀(Mn)-Mn-DP-diAsp);
- (133) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl (hereinafter referred to as C₁₀(Mn)-Mn-DP);
- (134) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl monoaspartic acid (hereinafter referred to as C₁₀(Mn)-Mn-DP-monoAsp);
- (135) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀(Mn)-Mn-DP-diAsp);
- (136) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl (hereinafter referred to as C₁₀(Mn)-Mn-DP);
- (137) 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀(Mn)-Mn-DP-diAsp);

- as C_{10(H2)}Citro)-Mn-DP-diAsp);
- (138) 2-(1-dihydrocitronellyloxyethyl)-4-ethenyl-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{10(H2)}Citro,mono)-Mn-DP-diAsp);
- (139) 2,4-bis(1-menthiloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as C_{10(Menthyl)}-Mn-DP);
- 5 (140) 2,4-bis(1-menthiloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{10(Menthyl)}-Mn-DP-diAsp);
- (141) 2,4-bis(1-undecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{11-Mn-DP-diAsp);}
- (142) 2,4-bis(1-dodecyloxyethyl)-Mn-deuteroporphyrin diglycine (hereinafter referred to as C_{12-Mn-DP-diGly);}
- 10 (143) 2,4-bis(1-dodecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{12-Mn-DP-diAsp);}
- (144) 2,4-bis(1-dodecyloxyethyl)-Mn-deuteroporphyrin diglutamic acid (hereinafter referred to as C_{12-Mn-DP-diGlu);}
- (145) 2,4-bis(1-dodecyloxyethyl)-Mn-deuteroporphyrin diasparyltetraglycine (hereinafter referred to as C_{12-Mn-DP-diAsp-tetraGly);}
- (146) 2,4-bis(1-dodecyloxyethyl)-Mn-deuteroporphyrin diasparyltetraaspatic acid (hereinafter referred to as C_{12-Mn-DP-diAsp-tetraAsp);}
- (147) 2-(1-dodecyloxyethyl)-4-ethenyl-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{12(mon)}-Mn-DP-diAsp);
- 20 (148) 2,4-bis(1-tridecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{13-Mn-DP-diAsp);}
- (149) 2,4-bis(1-tetradecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{14-Mn-DP-diAsp);}
- (150) 2,4-bis(1-tetradecyloxyethyl)-Mn-deuteroporphyrin diasparyltetraaspatic acid (hereinafter referred to as C_{14-Mn-DP-diAsp-tetraAsp);}
- 25 (151) 2,4-bis(1-farnesyloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as C_{15(Farnesyl)}-Mn-DP);
- (152) 2,4-bis(1-farnesyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{15(Farnesyl)}-Mn-DP-diAsp);
- (153) 2,4-bis(1-hexadecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{16-Mn-DP-diAsp);}
- (154) 2,4-bis(1-octadecyloxyethyl)-Mn-deuteroporphyrin diasparyltetraaspatic acid (hereinafter referred to as C_{18-Mn-DP-diAsp-tetraAsp);}
- (155) 2,4-bis(1-octadecyloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as C_{18(Oleyl)}-Mn-DP);
- 35 (156) 2,4-bis(1-octadecyloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as C_{18(Oleyl)}-Mn-DP-diAsp);
- (157) 2,4-bis(1-octadecyloxyethyl)-Mn-deuteroporphyrin diasparyltetraaspatic acid (hereinafter referred to as C_{18(Oleyl)}-Mn-DP-diAsp-tetraAsp);
- (158) 2,4-bis(1-phytyloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as C_{20(Phytyl)}-Mn-DP);
- 40 (159) 2,4-bis(1-tetrahydrofurfuryloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as H₄Fran-Mn-DP);
- (160) 2,4-bis(1-tetrahydrofurfuryloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as H₄Fran-Mn-DP-diAsp);
- (161) 2,4-bis[1-(tetrahydro-2-pyranmethyloxy)ethyl]-Mn-deuteroporphyrin (hereinafter referred to as H₄Pyran-Mn-DP);
- 45 (162) 2,4-bis[1-(tetrahydro-2-pyranmethyloxy)ethyl]-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as H₄Pyran-Mn-DP-diAsp);
- (163) 2,4-bis(1-nicotiniloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as Nct-Mn-DP);
- (164) 2,4-bis(1-nicotiniloxyethyl)-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as Nct-Mn-DP-diAsp);
- 50 (165) 2,4-bis[1-(2-methylthiopropoxy)ethyl]-Mn-deuteroporphyrin (hereinafter referred to as Msp-Mn-DP);
- (166) 2,4-bis[1-(2-methylthiopropoxy)ethyl]-Mn-deuteroporphyrin diaspatic acid (hereinafter referred to as Msp-Mn-DP-diAsp);
- 55 (167) 2,4-bis(1-octafluoropentyloxyethyl)-Mn-deuteroporphyrin (hereinafter referred to as C_{8(F18)}-Mn-DP);
- (168) 2,4-bis(1-octafluoropentyloxyethyl)-Mn-deuteroporphyrin diglycine (hereinafter referred to as C_{8(F18)}-Mn-DP-diGly);

- (169) 2-(1-octafluoropentyl-oxyethyl)-4-ethenyl-Mn-deuteroporphyrinyl diglycine (hereinafter referred to as $C_8(F_{18})$ -Mn-DP-dlGly);
- (170) 2,4-bis(1-octafluoropentyl-oxyethyl)-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as $C_8(F_{18})$ -Mn-DP-diAsp);
- 6 (171) 2-(1-octafluoropentyl-oxyethyl)-4-ethenyl-Mn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as $C_8(F_{18})$ -Mn-DP-diAsp);
- (172) 2,4-bis(1-geranyl-oxyethyl)-Mn-deuteroporphyrinyl di(p-trifluoromethyl)phenylalanyldiglutamic acid (hereinafter referred to as $C_{10}(Ger_{21})$ -Mn-DP-diPhe (F_3) -dlGlu);
- (173) 2,4-bis(1-dodecyl-oxyethyl)-Mn-deuteroporphyrinyl di(p-trifluoromethyl)phenylalanine (hereinafter referred to as C_{12} -Mn-DP-diPhe (F_3));
- 10 (174) 2,4-bis(1-dodecyl-oxyethyl)-Mn-deuteroporphyrinyl di(p-trifluoromethyl)phenylalanyldiglutamic acid (hereinafter referred to as C_{12} -Mn-DP-diPhe (F_3) -dlGlu);
- (175) 2-(1-dodecyl-oxyethyl)-4-ethenyl-Mn-deuteroporphyrinyl di(p-trifluoromethyl)phenylalanine (hereinafter referred to as $C_{12}(mono_{12})$ -Mn-DP-diPhe (F_3));
- 15 (176) Fe-protoporphyrinyl diglycine (hereinafter referred to as Fe-PP-dlGly);
- (177) 2-[1-(2-hydroxyethyl-oxy)ethyl]-4-ethenyl-Fe-deuteroporphyrin (hereinafter referred to as monoEG-Fe-DP);
- (178) 2-[1-(2-hydroxyethyl-oxy)ethyl]-4-ethenyl-Fe-deuteroporphyrinyl diglycine (hereinafter referred to as monoEG-Fe-DP-dlGly);
- 20 (179) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-Fe-deuteroporphyrinyl monodiaspartic acid (hereinafter referred to as EG-Fe-DP-monoAsp);
- (180) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-Fe-deuteroporphyrinyl diaspartic acid (hereinafter referred to as EG-Fe-DP-diAsp);
- (181) 2,4-bis(1-octyl-oxyethyl)-Fe-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_8 -Fe-DP-diAsp);
- 25 (182) 2,4-bis(1-decyl-oxyethyl)-Fe-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10} -Fe-DP-diAsp);
- (183) 2,4-bis(1-dodecyl-oxyethyl)-Fe-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{12} -Fe-DP-diAsp);
- 30 (184) 2-(1-dodecyl-oxyethyl)-4-ethenyl-Fe-deuteroporphyrinyl diaspartic acid (hereinafter referred to as $C_{12}(mono_{12})$ -Fe-DP-diAsp);
- (185) 2,4-bis(1-decyl-oxyethyl)-Co-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10} -Co-DP-diAsp);
- (186) 2,4-bis(1-dodecyl-oxyethyl)-Co-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{12} -Co-DP-diAsp);
- 35 (187) Cu-protoporphyrinyl monoserine (hereinafter referred to as Cu-PP-monoSer);
- (188) 2-[1-(2-hydroxyethyl-oxy)ethyl]-4-ethenyl-Cu-deuteroporphyrin (hereinafter referred to as monoEG-Cu-DP);
- (189) 2,4-bis(1-octyl-oxyethyl)-Cu-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_8 -Cu-DP-diAsp);
- 40 (190) 2,4-bis(1-decyl-oxyethyl)-Cu-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10} -Cu-DP-diAsp);
- (191) 2,4-bis(1-dodecyl-oxyethyl)-Cu-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{12} -Cu-DP-diAsp);
- 45 (192) Zn-protoporphyrinyl monophenylalanine (hereinafter referred to as Zn-PP-monoPhe);
- (193) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-Zn-deuteroporphyrin (hereinafter referred to as EG-Zn-DP);
- (194) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-Zn-deuteroporphyrinyl di-tyrosine (hereinafter referred to as EG-Zn-DP-diTyr);
- (195) 2,4-bis(1-octyl-oxyethyl)-Zn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_8 -Zn-DP-diAsp);
- 50 (196) 2,4-bis(1-decyl-oxyethyl)-Zn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{10} -Zn-DP-diAsp);
- (197) 2,4-bis(1-dodecyl-oxyethyl)-Zn-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C_{12} -Zn-DP-diAsp);
- 55 (198) In-protoporphyrinyl monotyrosine (hereinafter referred to as In-PP-monoTyr);
- (199) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-In-deuteroporphyrin (hereinafter referred to as EG-In-DP);
- (200) 2,4-bis[1-(2-hydroxyethyl-oxy)ethyl]-In-deuteroporphyrinyl di-tyrosine (hereinafter referred to as EG-In-DP-diTyr);

(201) 2,4-bis(1-octyloxyethyl)-in-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₈-in-DP-diAsp);

(202) 2,4-bis(1-decyloxyethyl)-in-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₀-in-DP-diAsp);

(203) 2,4-bis(1-dodecyloxyethyl)-in-deuteroporphyrinyl diaspartic acid (hereinafter referred to as C₁₂-in-DP-diAsp);

The metalloporphyrin compounds(I) of the present invention are particularly characterized in that they have at least one polyfunctional compound residue at the side chain of the porphyrin skeleton, and as a result they exert various physiological and pharmacological properties. An object of the present invention is to provide metalloporphyrin derivatives for diversified uses such as treatment and diagnoses of diseases, particularly cancer, by varying the metal within the porphyrin skeleton. For instance, a metalloporphyrin derivative with a long phosphorescence life time is used as a chemical which reacts intensely to an external energy (such as laser, microwave, electromagnetic wave, supersonic wave, and medium heat), while that with short phosphorescence life time is used singly as a diagnostic agent or an anti-tumor agent. These porphyrin derivatives accumulate selectively in tumor cells and are excreted therefrom very gradually. On the other hand, they are excreted from the normal organs and cells quickly and do not damage such organs and cells. Most porphyrin derivatives react intensely to light. Introduction of a polyfunctional compound residue to the side chain of a metalloporphyrin derivative according to the present invention promotes excretion from the normal tissues, and offers a derivative designed to maximally utilize the manifestation of phototoxicity while leaving intact selective accumulation property in tumor cells, and a derivative designed to maximally control manifestation of phototoxicity. Based on these properties (cancer affinity, non-phototoxicity, tumor cell necrosis effect of phototoxicity combined with an external energy, tumor cell necrosis effect by single use, etc), the present invention porphyrin derivatives are most useful as therapeutic and diagnostic agents for malignant tumors, as a tumor marker and as an agent for use in the missile therapy of cancers.

The compounds of the present invention are now explained in respect of their pharmacological effects and method of preparation by referring to the following examples.

Example 1

Laser Irradiation to the extirpated organ (excited fluorescent spectrum)

Golden hamsters (males, 5 per group, bodyweight approximately 150 g) were implanted subcutaneous-ly tumor cells of the nitrosoamine-induced pancreatic cancer. After 14 to 21 days following implantation, animals were intravenously (i.v.) administered the test substance EG-Ga-DP-diGly (14) (10 mg/ml) which had been diluted with phosphate buffer at 25 mg/kg bodyweight. At 24 hours after administration, the organs including the tumor were extirpated, irradiated with N₂-pulsed laser (N₂, 337 nm, 2 ns, 400 - 1000 nm), and measured of excited fluorescent spectrum. The wavelengths of 600 - 900 nm were studied using the peak wavelength of NADH at 470 nm as a reference. (N₂-PLS measurement). Table 2 shows the results obtained.

(Tumor to tissue ratio).

Excited fluorescent spectra of the organs extirpated at 24 hours after administration were measured, and the peak wavelength at 600 - 900 nm was calculated by setting the peak wavelength at 470 nm as the reference 1. The results are shown in Table 2. As fluorescence in Mn, Fe and Cu complexes is not sufficiently intense as to enable N₂-PLS measurement, the extraction method was applied to these compounds. At 24 hours following administration, the organs were extracted with an organic solvent (such as chloroform-methanol) via acetone powder, and the obtained extract was measured of UV or HPLC to calculate the tumor to tissue ratio.

As is clear from Table 2, these porphyrin related compounds were found to have a remarkable selective affinity to tumor cells.

Table 2

	tumor/tissue	cancer/ liver	cancer/ lung	cancer/ kidney	cancer/ serum
6	compound				
	(4) monoEG-Ga-DP-monoGly	1.75	2.00	3.50	2.30
	(5) monoEG-Ga-DP-diGly	1.64	1.35	1.94	-
10	(7) monoEG-Ga-DP-monoAsp	1.39	2.10	3.58	-
	(8) monoEG-Ga-DP-diAsp	2.30	1.50	1.32	-
	(10) monoEG-Ga-DP-diPhe	3.39	3.98	4.13	1.60
15	(12) monoEG-Ga-DP-diTyr	2.05	2.78	3.45	1.73
	(13) EG-Ga-DP-monoGly	2.24	1.56	2.40	1.53
	(14) EG-Ga-DP-diGly	1.38	1.42	2.44	-
20	(15) EG-Ga-DP-monoLeu	1.00	0.81	0.90	-
	(19) EG-Ga-DP-monoSer	2.18	0.40	3.25	0.26
	(22) EG-Ga-DP-monoAsp	1.59	1.25	1.71	-
25	(23) EG-Ga-DP-mono[D] Asp	1.70	1.34	1.92	-
	(24) EG-Ga-DP-diAsp	3.00	2.87	3.45	-
	(26) EG-Ga-DP-monoGlu	2.27	3.47	5.13	-
30	(29) EG-Ga-DP-monoPhe	2.80	3.45	3.66	1.05
	(30) EG-Ga-DP-diPhe	3.48	3.26	4.18	-
	(31) EG-Ga-DP-monoTyr	2.94	2.60	1.19	1.42
35	(32) EG-Ga-DP-diTyr	1.93	2.13	2.31	2.10
	(33) EG-Ga-DP-Gly·Asp	1.30	1.04	3.30	-
	(34) EG-Ga-DP-Ser·Asp	2.50	0.93	5.05	-
40	(35) EG-Ga-DP-Asp·Phe	1.00	3.83	-	-
	(36) EG-Ga-DP-Asp·Tyr	1.50	0.20	0.80	-
45	(44) C ₁ -Ga-DP-diAsp	1.19	0.78	2.27	2.50

	compound	tumor/tissue cancer/ liver	cancer/ lung	cancer/ kidney	cancer/ serum
5	(45) C ₁ -Ga-DP-monoTyr	1.26	1.19	2.54	-
	(48) C ₂ -Ga-DP-diAsp	0.71	1.25	1.25	1.16
	(49) C ₃ -Ga-DP-diAsp	2.95	3.42	14.44	5.91
10	(50) C ₃ (iso)-Ga-DP-diAsp	2.63	2.33	3.03	1.54
	(51) C ₄ -Ga-DP-diAsp	3.54	4.47	7.72	2.00
	(52) C ₅ -Ga-DP-diSer	2.70	1.82	3.23	1.47
15	(53) C ₅ -Ga-DP-diAsp	4.07	3.89	6.58	0.89
	(54) C ₆ -Ga-DP-diAsp	5.33	5.33	6.86	0.98
	(55) C ₇ -Ga-DP-diAsp	2.96	2.92	4.88	0.89
20	(56) C ₈ -Ga-DP-diGly	1.69	2.44	3.03	1.92
	(57) C ₈ -Ga-DP-diSer	1.64	1.59	3.85	1.30
	(58) C ₈ -Ga-DP-diAsp	1.47	2.20	2.12	0.29
25	(59) C ₈ -Ga-DP-diTyr	1.82	2.63	3.23	0.76
	(65) C ₈ (phenethyl)-Ga-DP-diAsp	3.79	2.89	3.79	0.72
	(66) C ₉ -Ga-DP-diAsp	2.07	3.40	3.54	1.12
30	(68) C ₁₀ -Ga-DP-diAsp	11.54	23.08	16.44	2.78
	(70) C ₁₀ (Gera)-Ga-DP-diAsp	3.33	4.88	3.82	2.19
	(72) C ₁₀ (Citro)-Ga-DP-diAsp	11.37	12.39	15.66	2.82
35	(74) C ₁₀ (H ₂ Citro)-Ga-DP-diAsp	9.09	11.11	11.49	3.50
	(77) C ₁₂ -Ga-DP-diAsp	4.38	7.00	8.54	1.35
	(78) C ₁₂ -Ga-DP-diGlu	2.00	4.00	4.00	-
40	(99) monoEG-Mn-DP-diGly	1.03	2.35	2.43	1.50

45 Example 2

in vivo hemorrhagic necrosis effect on the nitrosoamine-induced pancreatic cancer

50 Cancer bearing hamsters of Example 1 were i.v. administered the test substance C₆-Ga-DP-diAsp (54) (10 mg/ml) which had been diluted with phosphate buffer at 25 mg/kg bodyweight and 12.5 mg/kg bodyweight respectively. The animals were exsanguinated and autopsied at 24 hours after administration, and observed. The cancer mass of the treatment group developed hemorrhagic necrosis as shown in Figs. 1, 2 and 3. The organs such as the liver, lungs, kidneys of the treated group excluding the tumor and those of the control group (the group which was not administered the test substance) showed no changes.

55 Anti-tumor effect of the test material was evaluated by the intensity of hemorrhagic necrosis at 24 hours following administration of the test substance in the manner mentioned above and by the pathological study discussed in Example 3. The evaluation was based on the four scales of G₄, G₃, G₂ and G₁. The result is

shown in Table 3.

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Table 3

	Compound	Hemorrhagic necrosis effect
	(7) monoEG-Ga-DP-monoAsp	G ₁
	(8) monoEG-Ga-DP-diAsp	G ₁
10	(15) EG-Ga-DP-monoLeu	G ₁
	(22) EG-Ga-DP-monoAsp	G ₂
	(23) EG-Ga-DP-mono[D]Asp	G ₂
15	(26) EG-Ga-DP-monoGlu	G ₁
	(33) EG-Ga-DP-Gly·Asp	G ₂
	(34) EG-Ga-DP-Ser·Asp	G ₁
20	(35) EG-Ga-DP-Asp·Phe	G ₁
	(36) EG-Ga-DP-Asp·Tyr	G ₁
	(37) MC-Ga-DP-monoSer	G ₂
	(38) MC-Ga-DP-monoAsp	G ₁
25	(40) EC-Ga-DP-monoAsp	G ₁
	(43) C ₁ -Ga-DP-monoAsp	G ₁
	(44) C ₁ -Ga-DP-diAsp	G ₁
30	(47) C ₂ -Ga-DP-monoAsp	G ₁
	(48) C ₂ -Ga-DP-diAsp	G ₁
	(49) C ₃ -Ga-DP-diAsp	G ₂
35	(50) C ₃ (iso)-Ga-DP-diAsp	G ₂
	(51) C ₄ -Ga-DP-diAsp	G ₄
	(52) C ₅ -Ga-DP-diSer	G ₁
	(53) C ₅ -Ga-DP-diAsp	G ₄
40	(54) C ₆ -Ga-DP-diAsp	G ₄
	(55) C ₇ -Ga-DP-diAsp	G ₄
	(56) C ₈ -Ga-DP-diGly	G ₁
45	(57) C ₈ -Ga-DP-diSer	G ₁
	(58) C ₈ -Ga-DP-diAsp	G ₃
	(59) C ₈ -Ga-DP-diTyr	G ₁
50	(65) C ₈ (Phenethyl)-Ga-DP-diAsp	G ₁
	(66) C ₉ -Ga-DP-diAsp	G ₂
	(68) C ₁₀ -Ga-DP-diAsp	G ₂
	(70) C ₁₀ (Gera)-Ga-DP-diAsp	G ₂
55	(72) C ₁₀ (Citro)-Ga-DP-diAsp	G ₂

5	Compound	Hemorrhagic necrosis effect
	(74) C ₁₀ (H ₂ Citro)-Ga-DP-diAsp	G ₂
	(76) C ₁₂ -Ga-DP-diGly	G ₁
10	(77) C ₁₂ -Ga-DP-diAsp	G ₂
	(78) C ₁₂ -Ga-DP-diGlu	G ₁
	(108) EG-Mn-DP-monoAsp	G ₁
15	(115) C ₈ -Mn-DP-diGly	G ₁
	(116) C ₈ -Mn-DP-diAsp	G ₃
	(117) C ₁₀ -Mn-DP-diGly	G ₁
	(122) C ₁₀ -Mn-DP-diAsp	G ₃
20	(123) C ₁₀ -Mn-DP-d[D]Asp	G ₃
	(124) C ₁₀ -Mn-DP-diGlu	G ₁
	(126) C ₁₀ -Mn-DP-diGly-diAsp	G ₂
25	(127) C ₁₀ -Mn-DP-diLeu-diAsp	G ₂
	(128) C ₁₀ -Mn-DP-diPhe-diAsp	G ₂
	(132) C ₁₀ (Gera)-Mn-DP-diAsp	G ₃
	(134) C ₁₀ (Citro)-Mn-DP-monoAsp	G ₂
30	(135) C ₁₀ (Citro)-Mn-DP-diAsp	G ₃
	(137) C ₁₀ (H ₂ Citro)-Mn-DP-diAsp	G ₄
	(138) C ₁₀ (H ₂ Citro,mono)-Mn-DP-diAsp	G ₂
35	(143) C ₁₂ -Mn-DP-diAsp	G ₄
	(145) C ₁₂ -Mn-DP-diAsp-tetraGly	G ₂
	(147) C ₁₂ (mono)-Mn-DP-diAsp	G ₂
40	(149) C ₁₄ -Mn-DP-diAsp	G ₃
	(154) C ₁₈ -Mn-DP-diAsp-tetraAsp	G ₂
	(160) H ₄ Fran-Mn-DP-diAsp	G ₂
	(164) Nct-Mn-DP-diAsp	G ₂
45	(181) C ₈ -Fe-DP-diAsp	G ₃
	(183) C ₁₂ -Fe-DP-diAsp	G ₃
	(185) C ₁₀ -Co-DP-diAsp	G ₁
50	(186) C ₁₂ -Co-DP-diAsp	G ₁
	(191) C ₁₂ -Cu-DP-diAsp	G ₁
	(197) C ₁₂ -Zn-DP-diAsp	G ₂
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Example 3

Pathology

Tumor bearing hamsters of Example 1 were treated similarly as in Example 2 except that they were administered C_{12} -Mn-DP-diAsp (143) instead of C_6 -Ga-DP-diAsp (54). Organs including the tumor (the treated group and the control group) were fixed with formalin, embedded in paraffin, cut into sections, double stained with hematoxylin-eosin, and observed pathologically.

Figs. 4 and 5 show photographs of the tumor cell necrosis of the treated group. There were many cell necrosis images and necrotic layers which were not present in the non-cancerous organs and the control group.

Example 4

In vivo cell growth inhibition effect

Tumor bearing hamsters of Example 1 were i.v. administered the test substance C_{10} -Mn-DP-diAsp (122) (10 mg/ml) diluted by phosphate buffer at 25 mg/kg bodyweight. The tumor size was measured supracutaneously using slide callipers on an appropriate day following administration.

Method of calculation

$$\text{Volume} = 1/2 \times (\text{long diameter}) \times (\text{short diameter})^2$$

Fig. 6 shows tumor cell growth curves of the groups administered C_{10} -Mn-DP-diAsp (122) and C_{12} -Mn-DP-diAsp (143), and the control group. As is clear from these curves, both treated groups manifested notable tumor growth inhibitory effect compared to the control group, indicating the test substances had carcinostatic activities.

Example 5

In vitro photosensitivity test

Leukemia cells of a mouse (P388) were placed in wells (a plate with 24 wells) at 5×10^4 /well, and incubated for 2 hours. The test materials C_6 -Ga-DP-diAsp (58), C_{10} -Mn-DP-diAsp (122) and photofrin II each at concentrations of 1.56, 3.13, 6.25, 12.5, 25, and 50 ng/ml (common ratio : 2) were prepared. The specified amounts of these test solutions were added to the above culture, irradiated at 10,000 lux for 1 hour, incubated for 48 hours, and the cells per one well were counted. A group shielded from light using an aluminium foil during irradiation was provided as control. The index of photosensitivity was obtained by dividing the cell counts of the respective groups with the cell count of an untreated group provided separately (cell growth inhibition ratio (%)).

Fig. 7 shows the cell growth inhibition ratio. As is clear from the figure, the irradiated groups treated with Ga complex showed a higher inhibition ratio compared to the control group, manifesting photosensitivity at 1.0 ng/ml or above. As for the groups treated with Mn complex, there was observed no distinct difference in inhibition ratio between the treated groups and the control group, thus indicating no photosensitivity. The inhibition ratio was observed to elevate at concentration of 12.5 ng/ml or higher for each of the test materials. However, this was attributed to the toxicity of the test material per se rather than to irradiation.

Example 6

In vivo irradiation therapy using Yag laser

Tumor bearing hamsters of Example 1 were i.v. administered the test materials C_6 -Ga-DP-diAsp (54)

and C₁₀-Ga-DP-diAsp (68) (10 mg/ml) at 12.5 mg/kg bodyweight. At 24 hours after administration, the hair above the tumor site was shaved and irradiation with Yag laser commenced (1064 nm, 5 w, 10 sec x 4). At 24 hours following irradiation, the animals were exsanguinated and autopsied for observation. As is clear from Figs. 8 and 9, the cancer mass of the groups administered the test materials was necrotic, while that of the control group (untreated group) showed no such changes.

It is therefore clear that the present invention substance is effective for a therapy using an external energy such as Yag laser.

10 Example 7

To 1 g of DCHA salt of Ga-protoporphyrin (hereinafter referred to as DCHA salt of Ga-PP) were added and dissolved 60 ml of chloroform and 10 ml of tetrahydrofuran. To the resultant solution was added 0.5 g of glycine ethyl ester hydrochloride (hereinafter referred to as Gly(OEt)*HCl). The obtained solution was then gradually added with 0.1 g of WSC while stirring, and reacted for 2 hours. After the reaction was completed (confirmed by TLC [chloroform : methanol (4 : 1)]), the reaction solution was washed with water to recover the unreacted substance. After separation, the chloroform layer was concentrated. The obtained concentrate was recrystallized with ethanol ethyl acetate to obtain 0.12 g of Ga-PP-monoGly(OEt) (ethyl ester of 1). The yield was 16.4%.

Example 8

To 0.1 g of ethyl ester of 1 was added 1/2 N KOH alcohol until the hydrolysis reaction was completed. After the reaction was completed (confirmed by TLC), 10% citric acid solution was added to adjust pH to 5.5, and the resultant solution was extracted with chloroform and concentrated. The resultant concentrate was recrystallized with methanol ethyl acetate to obtain 0.11 g of Ga-PP-monoGly (1). The yield was 98.0%.

30 Example 9

To 0.38 g of DCHA salt of Ga-PP were added and dissolved 10 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.38 g of tyrosine methyl ester hydrochloride (hereinafter referred to as Tyr(OMe)*HCl), and then gradually 0.38 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.22 g of Ga-PP-diTyr (3). The yield was 60.0%.

Example 10

To 2 g of DCHA salt of 2[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-deuteroporphyrin (hereinafter referred to as DCHA salt of monoEG-Ga-DP) were added and dissolved 300 ml of chloroform and 150 ml of acetonitrile. To the resultant solution were added 2 g of Gly(OEt)*HCl dissolved in 20 ml of water, and then gradually 14 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.11 g of monoEG-Ga-DP-monoGly (4). The yield was 7.4%.

Example 11

To 1.6 g of DCHA salt of monoEG-Ga-DP were added and dissolved 60 ml of chloroform and 30 ml of acetonitrile. To the resultant solution were added 0.75 g of Gly(OEt)*HCl, and then gradually 1.3 g of dicyclohexylcarbodiimide (hereinafter referred to as DDC) while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 1.11 g of monoEG-Ga-DP-diGly (5). The yield was 89.8%.

Example 12

To 1 g of DCHA salt of monoEG-Ga-DP were added and dissolved 10 ml of chloroform and 20 ml of acetonitrile. To the resultant solution were added 2 g of aspartic acid dimethyl ester hydrochloride (hereinafter referred to as Asp(OMe)*HCl) dissolved in 0.5 ml of dimethylformamide (hereinafter referred to as DMF), and then gradually 2 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.25 g of monoEG-Ga-DP-monoAsp (7). The yield was 32.3%.

Example 13

To 5 g of DCHA salt of monoEG-Ga-DP were added and dissolved 50 ml of chloroform and 100 ml of acetonitrile. To the resultant solution were added 5 ml of 50% Asp(OMe)*HCl DMF solution, and then gradually 3.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 3.8 g of monoEG-Ga-DP-dAsp (8). The yield was 88.5%.

Example 14

To 10 g of DCHA salt of monoEG-Ga-DP were added and dissolved 280 ml of chloroform and 140 ml of acetonitrile. To the resultant solution were added 10 g of phenylalanine methyl ester hydrochloride (hereinafter referred to as Phe(OMe)*HCl), and then gradually 8 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 8.3 g of monoEG-Ga-DP-dPhe (10). The yield was 89.8%.

Example 15

To 3 g of DCHA salt of monoEG-Ga-DP were added and dissolved 150 ml of chloroform and 150 ml of acetonitrile. To the resultant solution were added 3 g of Tyr(OMe)*HCl dissolved in 3 ml of water, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.82 g of monoEG-Ga-DP-monoTyr (11). The yield was 24.9%.

Example 16

To 1.07 g of DCHA salt of monoEG-Ga-DP were added and dissolved 45 ml of chloroform and 15 ml of acetonitrile. To the resultant solution were added 1 g of Tyr(OMe)*HCl, and then gradually 1 of DCC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 1.01 g of monoEG-Ga-DP-dTyr (12). The yield was 97.6%.

Example 17

To 150 g of Ga-protoporphyrin dimethyl ester (hereinafter referred to as Ga-PP-Me) was added 1.5 liter of 8% hydrobromic acid/acetic acid (hereinafter referred to as HBr/HOAc). The resultant solution was left standing for 24 hours, concentrated under reduced pressure at below 50 °C, and the Br derivatives obtained as a result of concentration was added with ethyleneglycol and left standing for 24 hours. After reaction was completed (confirmed by TLC), the product was washed with water, hydrolyzed and recrystallized (acetonethyl acetate) to obtain 90 g of 2,4-bis[1-(2-hydroxyethyloxy)ethyl]-Ga-deuteroporphyrin (hereinafter referred to as EG-Ga-DP). The yield was 50.6%.

Example 18

To 1 g of DCHA salt of EG-Ga-DP obtained in Example 17 were added and dissolved 100 ml of chloroform and 100 ml of acetonitrile. To the resultant solution were added 1 g of Gly(OEt)*HCl dissolved in 10 ml of water, and then gradually 10 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.2 g of EG-Ga-DP-monoGly (13).

The yield was 27.2%.

Example 19

To 0.5 g of DCHA salt of EG-Ga-DP were added and dissolved 20 ml of chloroform and 10 ml of acetonitrile. To the resultant solution were added 0.25 g of Gly(OEt)*HCl, and then gradually 0.4 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.28 g of EG-Ga-DP-diGly (14). The yield was 71.4%.

Example 20

To 2 g of DCHA salt of EG-Ga-DP were added and dissolved 20 ml of chloroform and 60 ml of acetonitrile. To the resultant solution were added 1 g of leucine methyl ester hydrochloride (hereinafter referred to as Leu(OMe)*HCl) dissolved in 5 ml of DMF, and then gradually 2 ml of 3% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.15 g of EG-Ga-DP-monoLeu (15). The yield was 9.6%.

Example 21

To 2 g of DCHA salt of EG-Ga-DP were added and dissolved 20 ml of chloroform and 60 ml of acetonitrile. To the resultant solution were added 1 g of Leu(OMe)*HCl dissolved in 5 ml of DMF, and then gradually 2 ml of 3% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.21 g of EG-Ga-DP-diLeu (16). The yield was 11.9%.

Example 22

To 2 g of DCHA salt of EG-Ga-DP were added and dissolved 30 ml of chloroform and 30 ml of acetonitrile. To the resultant solution were added 1 g of serine methyl ester hydrochloride (hereinafter referred to as Ser(OMe)*HCl) dissolved in 4 ml of DMF, and then gradually 6 ml of 6% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.49 g of EG-Ga-DP-monoSer (19). The yield was 11.8%.

Example 23

To 25 g of DCHA salt of EG-Ga-DP were added and dissolved 250 ml of chloroform and 500 ml of acetonitrile. To the resultant solution were added 12 g of Asp(OMe)*HCl dissolved in 13 ml of DMF, and then gradually 32.5 ml of 10% WSC chloroform solution while stirring. When the reaction was completed after 70 minutes (confirmed with TLC), the reaction liquid was washed with water, extracted and divided with 4% NaHCO₃ solution, and added with 10% citric acid solution to the water layer to adjust pH to 5.5. The pH-adjusted water layer was extracted with chloroform and concentrated under reduced pressure to obtain 6.83 g of methyl ester of EG-Ga-DP-monoAsp (22). By concentrating the chloroform layer under reduced pressure, 2.3 g of methyl ester of EG-Ga-DP-diAsp (24) was also obtained. Hydrolysis was performed similarly as in Example 8 on 0.1 g each of esters to obtain 70 mg of EG-Ga-DP-monoAsp (22) and 50 mg of EG-Ga-DP-diAsp (24). The yields were 23.6% and 5.2% respectively.

Example 24

To 5 g of DCHA salt of EG-Ga-DP were added and dissolved 50 ml of chloroform and 100 ml of acetonitrile. To the resultant solution were added 2.5 g of [D]Asp(OMe)*HCl dissolved in 2.5 ml of DMF, and then gradually 18 ml of 5% WSC chloroform solution while cooling and stirring. The procedure similar to that of Example 23 was thereafter followed to obtain 0.75 g of EG-Ga-DP-mono[D]Asp (23). The yield was 20.1%.

Example 25

To 1 g of DCHA salt of EG-Ga-DP were added and dissolved 10 ml of chloroform and 20 ml of acetonitrile. To the resultant solution were added 0.5 g of glytamic acid diethyl ester hydrochloride (hereinafter referred to Glu(OEt)*HCl) dissolved in 0.5 ml of DMF, and then gradually 4 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 42 mg of EG-Ga-DP-monoGlu (26). The yield was 5.27%.

10 Example 26

To 0.5 g of DCHA salt of EG-Ga-DP were added and dissolved 12 ml of chloroform and 20 ml of acetonitrile. To the resultant solution were added 0.5 g of lysine methyl ester hydrochloride (hereinafter referred to as Lys(OMe)*HCl) dissolved in 10 ml of DMF, and then gradually 5 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 80 mg of EG-Ga-DP-monoLys (28). The yield was 20.1%.

20 Example 27

To 0.5 g of DCHA salt of EG-Ga-DP were added and dissolved 30 ml of chloroform and 30 ml of acetonitrile. To the resultant solution were added 0.5 g of Phe(OMe)*HCl dissolved in 30 ml of water, and then gradually 5 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.24 g of EG-Ga-DP-monoPhe (29). The yield was 59.0 %.

30 Example 28

To 0.5 g of DCHA salt of EG-Ga-DP were added and dissolved 40 ml of chloroform and 13 ml of acetonitrile. To the resultant solution were added 0.5 g of Phe(OMe)*HCl, and then gradually 5 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.38 g of EG-Ga-DP-diPhe (30). The yield was 80.8%.

35 Example 29

To 5 g of EG-Ga-DP were added and dissolved 150 ml of chloroform, 25 ml of acetonitrile, and 15 ml of DMF. To the resultant solution were added 5 g of Tyr(OMe)*HCl dissolved in 15 ml of DMF, and then gradually 15 ml of 5% DCC chloroform solution while stirring. The procedure similar to that of Example 8 was thereafter followed to obtain 1.4 g of EG-Ga-DP-monoTyr (31). The yield was 23.2%.

40 Example 30

To 1 g of DCHA salt of EG-Ga-DP were added and dissolved 40 ml of chloroform and 20 ml of acetonitrile. To the resultant solution were added 1 g of Tyr(OMe)*HCl, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.78 g of EG-Ga-DP-diTyr (32). The yield was 80.5%.

45 Example 31

To 0.2 g of DCHA salt of EG-Ga-DP-monoGly (13) ethyl ester obtained in Example 18 were added and dissolved 8 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.2 g of Asp(OMe)*HCl, and then gradually 0.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.11 g of EG-Ga-DP-Gly*Asp (33). The yield was 62.8%.

Example 32

To 0.2 g of DCHA salt of EG-Ga-DP-monoAsp (22) methyl ester obtained in Example 23 were added and dissolved 8 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.2 g of Ser-(OMe)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 70 mg of EG-Ga-DP-Ser*Asp (34). The yield was 39.3%.

Example 33

To 0.2 g of DCHA salt of EG-Ga-DP-monoAsp (22) methyl ester obtained in Example 23 were added and dissolved 8 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.2 g of Phe-(OMe)*HCl, and then gradually 0.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.17 g of EG-Ga-DP-Asp*Phe (35). The yield was 61.8%.

Example 34

To 0.2 g of DCHA salt of EG-Ga-DP-monoTyr (31) methyl ester obtained in Example 29 were added and dissolved 8 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.2 g of Asp-(OMe)*HCl, and then gradually 0.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.1 g of EG-Ga-DP-Asp*Tyr (36). The yield was 52.9%.

Example 35

The procedure similar to Example 17 was followed using 10 g of Ga-PP-Me and 100 ml of 6% HBr/HOAc, and 50 ml each of methyl cellosolve and ethyl cellosolve (hereinafter respectively referred to as MC and EC) instead of ethylene glycol. There were obtained 2.3 g and 1.63 g of 2,4-bis[1-(2-methoxyethoxy)ethyl]-Ga-deuteroporphyrin and 2,4-bis[1-(2-ethoxyethoxy)ethyl]-Ga-deuteroporphyrin (hereinafter respectively referred to as MC-Ga-DP and EC-Ga-DP). The yields were 28.1% and 12.8% respectively.

Example 36

To 0.8 g of DCHA salt of MC-Ga-DP obtained in Example 35 were added and dissolved 8 ml of chloroform and 16 ml of acetonitrile. To the resultant solution were added 0.4 g of Asp(OMe)*HCl dissolved in 0.4 ml of DMF, and then gradually 3 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.13 g of MC-Ga-DP-monoAsp (38). The yield was 20.5%.

Example 37

To 0.8 g of DCHA salt of EC-Ga-DP obtained in Example 35 were added and dissolved 8 ml of chloroform and 16 ml of acetonitrile. To the resultant solution were added 0.4 g of Asp(OMe)*HCl dissolved in 0.4 ml of DMF, and then gradually 1 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.21 g of EC-Ga-DP-monoAsp (40). The yield was 33.0%.

Example 38

The procedure similar to Example 17 was followed using 8 g of Ga-PP-Me and 80 ml of 10% HBr/HOAc, and 30 ml each of methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, butyl alcohol, pentyl alcohol, hexyl alcohol, heptyl alcohol, octyl alcohol, nonyl alcohol, decyl alcohol and dodecyl alcohol separately instead of ethylene glycol. After hydrolysis, the first two were recrystallized (methanol - ethyl

acetate) and the remaining ten were passed through silica gel column chromatography (ethyl acetate - hexane) and recrystallized to obtain respectively 1.0 g, 0.45 g, 2.7 g, 1.3 g, 2.8 g, 2.0 g, 1.6 g, 4.0 g, 1.4 g, 0.84 g, 0.66 g and 2.0 g of 2,4-bis(1-methoxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-ethoxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-propoxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-isopropoxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-butoxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-pentyloxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-hexyloxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-heptyloxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-octyloxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-nonyloxyethyl)-Ga-deuteroporphyrin, 2,4-bis(1-decyloxyethyl)-Ga-deuteroporphyrin, and 2,4-bis(1-dodecyloxyethyl)-Ga-deuteroporphyrin (hereinafter respectively referred to as C₁-Ga-DP, C₂-Ga-DP, C₃-Ga-DP, C_{3(iso)}-Ga-DP, C₄-Ga-DP, C₅-Ga-DP, C₆-Ga-DP, C₇-Ga-DP, C₈-Ga-DP, C₉-Ga-DP, C₁₀-Ga-DP and C₁₂-Ga-DP). The yields were respectively 15.2%, 6.6%, 38.0%, 18.4%, 38.1%, 26.4%, 20.4%, 49.9%, 16.4%, 9.8%, 7.5% and 21.3%.

Example 39

To 0.5 g of DCHA salt of C₁-Ga-DP obtained in Example 38 were added and dissolved 5 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.5 g of Asp(OMe)*HCl and then gradually 0.51 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.44 g of C₁-Ga-DP-diAsp (44). The yield was 100%.

Example 40

To 0.5 g of DCHA salt of C₁-Ga-DP were added and dissolved 30 ml of chloroform and 30 ml of acetonitrile. To the resultant solution were added 0.5 g of Tyr(OMe)*HCl dissolved in 3.5 ml of water, and then gradually 3 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.14 g of C₁-Ga-DP-monoTyr (45). The yield was 34.3%.

Example 41

To 0.5 g of DCHA salt of C₂-Ga-DP obtained in Example 38 were added and dissolved 5 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.5 g of Asp(OMe)*HCl, and then gradually 0.47 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.42 g of C₂-Ga-DP-diAsp (48). The yield was 95.2%.

Example 42

To 0.5 g of DCHA salt of C₃-Ga-DP obtained in Example 38 were added and dissolved 5 ml of chloroform and 2.5 ml of acetonitrile. To the resultant solution were added 0.75 g of Asp(OMe)*HCl, and then gradually 0.52 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.32 g of C₃-Ga-DP-diAsp (49). The yield was 72.2%.

Example 43

To 0.2 g of DCHA salt of C_{3(iso)}-Ga-DP obtained in Example 38 were added and dissolved 4.5 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.2 g of Asp(OMe)*HCl, and then gradually 0.31 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.11 g of C_{3(iso)}-Ga-DP-diAsp (50). The yield was 82.2%.

Example 44

To 0.5 g of DCHA salt of C₄-Ga-DP obtained in Example 38 were added and dissolved 5 ml of chloroform and 2.5 ml of acetonitrile. To the resultant solution were added 0.75 g of Asp(OMe)*HCl, and

then gradually 0.59 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.44 g of C₆-Ga-DP-diAsp (51). The yield was 100%.

6 Example 45

To 0.3 g of DCHA salt of C₅-Ga-DP obtained in Example 38 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.2 g of Ser(OMe)*HCl, and then gradually 4 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7
10 and 8 was thereafter followed to obtain 0.22 g of C₅-Ga-DP-diSer (52). The yield was 86.8%.

Example 46

To 0.2 g of DCHA salt of C₅-Ga-DP were added and dissolved 4.5 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.2 g of Asp(OMe)*HCl, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.17 g
15 of C₅-Ga-DP-diAsp (53). The yield was 95.5%.

20 Example 47

To 0.75 g of DCHA salt of C₆-Ga-DP obtained in Example 38 were added and dissolved 14 ml of chloroform and 7 ml of acetonitrile. To the resultant solution were added 1 g of Asp(OMe)*HCl, and then
25 gradually 0.68 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.5 g of C₆-Ga-DP-diAsp (54). The yield was 74.8%.

Example 48

To 0.43 g of DCHA salt of C₇-Ga-DP obtained in Example 38 were added and dissolved 4 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.44 g of Asp(OMe)*HCl, and then
30 gradually 0.59 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.34 g of C₇-Ga-DP-diAsp (55). The yield was 88.3%.

Example 49

To 2 g of DCHA salt of C₈-Ga-DP obtained in Example 38 were added and dissolved 45 ml of chloroform and 15 ml of acetonitrile. To the resultant solution were added 2 g of Gly(OEt)*HCl, and then
40 gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.4 g of C₈-Ga-DP-diGly (56). The yield was 26.8%.

45 Example 50

To 1 g of DCHA salt of C₈-Ga-DP were added and dissolved 15 ml of chloroform and 15 ml of acetonitrile. To the resultant solution were added 0.5 g of Ser(OMe)*HCl, and then gradually 10 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter
50 followed to obtain 0.74 g of C₈-Ga-DP-diSer (57). The yield was 86.5%.

Example 51

To 1.5 g of DCHA salt of C₉-Ga-DP were added and dissolved 80 ml of chloroform and 30 ml of acetonitrile. To the resultant solution were added 2 g of Asp(OMe)*HCl, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.16 g
55 of C₉-Ga-DP-diAsp (58). The yield was 12.7%.

Example 52

To 1.5 g of DCHA salt of C_8 -Ga-DP were added and dissolved 45 ml of chloroform and 15 ml of acetonitrile. To the resultant solution were added 1.5 g of $Tyr(OMe)^*HCl$, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.28 g of C_8 -Ga-DP-diTyr (59). The yield was 20.3%.

Example 53

The procedure similar to that of Example 17 was followed using 6 g of Ga-PP-Me and 60 ml of 3% $HBr/HOAc$, and 30 ml of octyl alcohol instead of ethylene glycol. After hydrolysis, the resultant substance was passed through silica gel column chromatography (ethyl acetate - hexane), and recrystallized to obtain 0.99 g of the mixture of C_8 -Ga-DP and 2-(1-octyloxyethyl)-4-ethenyl-Ga-deuteroporphyrin (hereinafter referred to as $C_8(mono)$ -Ga-DP). The yield was 11.7%.

Example 54

To 2 g of DCHA salt of the C_8 -Ga-DP and $C_8(mono)$ -Ga-DP mixture obtained in Example 53 were added 45 ml of chloroform and 45 ml of acetonitrile. To the resultant solution were added 2 g of $Gly(OEt)^*HCl$, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain Gly derivative mixture. The mixture was then passed through OS (C_8) high performance liquid chromatography [eluent, $MeOH-H_2O$ (9:1)] to obtain 0.005 g of $C_8(mono)$ -Ga-diGly (60). The yield was 0.3%.

Example 55

To 6 g of DCHA salt of the mixture of C_8 -Ga-DP and $C_8(mono)$ -Ga-DP was added and dissolved 120 ml of chloroform. To the resultant solution were added 8 g of $Asp(OMe)^*HCl$, and then gradually 5.5 g of WSC while stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain 0.3 g of $C_8(mono)$ -Ga-diAsp (62). The yield was 6.3%.

Example 56

To 1.5 g of DCHA salt of the mixture of C_8 -Ga-DP and $C_8(mono)$ -Ga-DP were added and dissolved 45 ml of chloroform and 15 ml of acetonitrile. To the resultant solution were added 1.5 g of $Tyr(OMe)^*HCl$, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain 0.013 g of $C_8(mono)$ -Ga-diTyr (63). The yield was 0.9%.

Example 57

The procedure similar to Example 17 was followed using 6 g of Ga-DP-Me and 60 ml of 10% $HBr/HOAc$, and 30 ml of phenethyl alcohol instead of ethylene glycol. After hydrolysis, the resultant substance was passed through silica gel column chromatography (ethyl acetate - hexane) and recrystallized to obtain 2.9 g of $C_8(phenethyl)$ -Ga-DP (64). The yield was 66.1%.

Example 58

To 0.2 g of DCHA salt of (64) obtained in Example 57 were added and dissolved 4.5 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.2 g of $Asp(OMe)^*HCl$, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.06 g of $C_8(phenethyl)$ -Ga-DP-diAsp (65). The yield was 33.5%.

Example 59

To 0.17 g of DCHA salt of C_9 -Ga-DP obtained in Example 38 were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.2 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.27 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.15 g of C_9 -Ga-DP-diAsp (66). The yield was 98.0%.

Example 60

To 0.38 g of DCHA salt of C_{10} -Ga-DP obtained in Example 38 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.2 g of $\text{Ser(OMe)}^*\text{HCl}$, and then gradually 4 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.29 g of C_{10} -Ga-DP-diSer (67). The yield was 88.6%.

Example 61

To 0.54 g of DCHA salt of C_{10} -Ga-DP were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.54 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.54 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.48 g of C_{10} -Ga-DP-diAsp (68). The yield was 98.4%.

Example 62

The procedure similar to Example 17 was followed using 4.5 g of Ga-PP-Me and 45 ml of 10% HBr/HOAc , and 25 ml of geraniol instead of ethylene glycol. After hydrolysis, the resultant substance was passed through silica gel column chromatography (ethyl acetate - hexane), and recrystallized to obtain 1.0 g of $C_{10}(\text{Geran})$ -Ga-DP (69). The yield was 15.2%.

Example 63

To 0.5 g of DCHA salt of (69) were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.5 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.73 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.42 g of $C_{10}(\text{Geran})$ -Ga-DP-diAsp (70). The yield was 93.1%.

Example 64

The procedure similar to those of Examples 17 and 62 was followed using 3 g of Ga-PP-Me and 30 ml of 10% HBr/HOAc , and 18 ml of citronellol instead of ethylene glycol to obtain 1.4 g of $C_{10}(\text{Citro})$ -Ga-DP (71). The yield was 31.8%.

Example 65

To 0.5 g of DCHA salt of (71) were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.5 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.72 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.43 g of $C_{10}(\text{Citro})$ -Ga-DP-diAsp (72). The yield was 95.3%.

Example 66

The procedure similar to Examples 17 and 62 was followed using 3 g of Ga-PP-Me and 30 ml of 10%

HBr/HOAc, and 18 ml of dihydrochloronellol instead of ethylene glycol to obtain 1.1 g of $C_{10}H_{22}Cl_2$ -Ga-DP (73). The yield was 24.8%.

6 Example 67

To 0.5 g of DCHA salt of (73) were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.5 g of $Asp(OMe)^*HCl$, and then gradually 0.72 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.42 g of $C_{10}(H_2Cl_2O)_2$ -Ga-DP-diAsp (74). The yield was 93.8%.

Example 68

To 1 g of DCHA salt of C_{12} -Ga-DP obtained in Example 38 were added and dissolved 20 ml of chloroform and 10 ml of acetonitrile. To the resultant solution were added 1 g of $Gly(OEt)^*HCl$, and then gradually 0.93 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.82 g of C_{12} -Ga-DP-diGly (76). The yield was 100%.

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Example 69

To 0.5 g of DCHA salt of C_{12} -Ga-DP were added and dissolved 5 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 5 g of $Asp(OMe)^*HCl$, and then gradually 0.35 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.44 g of C_{12} -Ga-DP-diAsp (77). The yield was 97.1%.

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Example 70

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To 0.5 g of DCHA salt of C_{12} -Ga-DP were added and dissolved 5 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.75 g of $Glu(OEt)^*HCl$, and then gradually 0.44 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.46 g of C_{12} -Ga-DP-diGlu (78). The yield was 99.4%.

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Example 71

The procedure similar to those of Examples 17 and 62 was followed using 4.5 g of Ga-PP-Me and 45 ml of 10% HBr/HOAc, and 25 ml each of tetrahydrofurfuryl alcohol and tetrahydropyran-2-methanol instead of ethylene glycol to obtain 3.3 g of H_4 Fran-Ga-DP (79) and 3.2 g of H_4 Pyran-Ga-DP (81). The yields were 55.9% and 52.4% respectively.

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Example 72

To 0.2 g of DCHA salt of (79) obtained in Example 71 were added and dissolved 4 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.3 g of $Asp(OMe)^*HCl$, and then gradually 0.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.17 g of H_4 Fran-Ga-DP-diAsp (80). The yield was 95.1%.

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Example 73

To 0.3 g of DCHA salt of (81) obtained in Example 71 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.4 g of $Asp(OMe)^*HCl$, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.25 g of H_4 Pyran-Ga-DP-diAsp (82). The yield was 92.9%.

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Example 74

To 0.3 g of DCHA salt of Mg-protoporphyrin were added and dissolved 20 ml of chloroform and 1 ml of pyridine. To the resultant solution were added 0.3 g of Tyr(OMe)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.1 g of Mg-PP-diTyr (88). The yield was 34.6%.

Example 75

The procedure similar to those of Examples 17 and 62 was followed using 3 g of PP-Me and 30 ml of 10% HBr/HOAc, and 18 ml each of ethylene glycol, octyl alcohol, decyl alcohol, undecyl alcohol, dodecyl alcohol, tetradecyl alcohol, hexadecyl alcohol and octadecyl alcohol separately to obtain 3.2 g, 1.78 g, 1.0 g, 0.89 g, 1.12 g, 0.75 g, 0.09 g, and 0.8 g of 2,4-bis[1-(2-hydroxyethyloxy)ethyl]deuteroporphyrin, 2,4-bis(1-octyloxyethyl)deuteroporphyrin, 2,4-bis(1-decyloxyethyl)deuteroporphyrin, 2,4-bis(1-undecyloxyethyl)deuteroporphyrin, 2,4-bis(1-dodecyloxyethyl)deuteroporphyrin, 2,4-bis(1-tetradecyloxyethyl)deuteroporphyrin, 2,4-bis(1-hexadecyloxyethyl)deuteroporphyrin, and 2,4-bis(1-octadecyloxyethyl)deuteroporphyrin (hereinafter referred to as EG-DP, C₈-DP, C₁₀-DP, C₁₁-DP, C₁₂-DP, C₁₄-DP, C₁₆-DP, and C₁₈-DP respectively). The yields were respectively 88.9%, 42.6%, 22.4%, 19.1%, 23.6%, 14.9%, 1.7% and 14.3%.

Example 76

To 6 g of EG-DP obtained in Example 75 was added 1 liter of pyridine, and suspended with 40 g of magnesium perchlorate. The mixture was then reacted for 3.5 hours under heating (at 115°C). After concentration, the reaction solution was added with water to precipitate crystals. The obtained precipitates were filtered off, dried and then hydrolyzed as in Example 8 to obtain 2.7 g of EG-Mg-DP (89). The yield was 43.5%.

Example 77

To 0.4 g of DCHA salt of (89) was added and dissolved 24 ml of tetrahydrofuran. To the resultant solution were added 0.4 g of Tyr(OMe)*HCl, and then gradually 85 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.12 g of EG-Mg-DP-diTyr (90). The yield was 23.0%.

Example 78

To 20 ml of acetic acid were added 1 g of PP-Me, 1 g of manganese acetate and 1 g of sodium acetate, suspended, and then reacted for 20 minutes under heating (75 - 78°C). After reaction (confirmed by TLC), the reaction solution was added with water to precipitate crystals. The obtained precipitates were filtered off, dried and then hydrolyzed as in Example 8 to obtain 0.74 g of Mn-protoporphyrin (hereinafter referred to as Mn-PP). The yield was 70.8%.

Example 79

To 0.8 g of DCHA salt of Mn-PP obtained in Example 78 were added and dissolved 40 ml of chloroform and 2 ml of pyridine. To the resultant solution were added 0.6 g of Tyr(OMe)*HCl, and then gradually 0.6 g of WSC while stirring. The procedure similar to that of Example 23 was thereafter followed to obtain 0.1 g of Mn-PP-monoTyr(OMe) (methyl ester of 95). The yield was 20.6%.

Example 80

To esters obtained in Example 79 was added 0.1N NaOH, and the resultant substance was heated

slightly and hydrolyzed. After the completion of reaction (confirmed by TLC), the procedure similar to that of Example 8 was followed to obtain 0.09 g of Mn-PP-monoTyr (95). The yield was 91.6%.

5 Example 81

To 0.3 g of DCHA salt of Mn-PP were added and dissolved 20 ml of chloroform and 1 ml of pyridine. To the resultant solution were added 0.3 g of Tyr(OMe)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 80 was thereafter followed to obtain 0.1 g of Mn-PP-diTyr (96). The yield was 37.3%.

Example 82

15 To 10 g each of 2-[1-(2-hydroxyethyloxy)ethyl]-4-ethenyl-deuteroporphyrin (hereinafter referred to as monoEG-DP) and EG-DP were added and dissolved separately 60 ml of chloroform and 20 ml of methanol. To the resultant substances were respectively added 10.2 g of manganese acetate dissolved in 8 ml of methanol while stirring, heated and reacted at 70 - 75 °C. After reaction (confirmed by TLC), the reaction solution was concentrated under reduced pressure. The obtained concentrate was then washed with water, 20 filtered, and the filtrate was dried to obtain 2.2 g of monoEG-Mn-DP (97) and 2.35 g of EG-Mn-DP (103) respectively. The yields were 22.0% and 20.8%.

Example 83

25 To 4 g of DCHA salt of (97) were added and dissolved 120 ml of chloroform and 60 ml of acetonitrile. To the resultant solution were added 3 g of Gly(OEt)*HCl, and then gradually 4 g of WSC while stirring. The reaction was carried out for 80 minutes. After reaction was completed (confirmed by TLC), the reaction solution was washed with water, extracted with 4% NaHCO₃ solution and divided. To the water layer was added 10% citric acid solution to adjust pH to 5.5. Thus adjusted water layer was extracted with chloroform, and concentrated under reduced pressure to obtain ethyl ester of monoEG-Mn-DP-monoGly (98). On the other hand, the chloroform layer was also concentrated under reduced pressure to obtain ethyl ester of monoEG-Mn-DP-diGly (99). The procedure similar to Example 8 was followed to hydrolyze respective esters to obtain 1.2 g of monoEG-Mn-DP-monoGly (98) and 1.5 g of monoEG-Mn-DP-diGly (99). The yields were 35 45.1% and 52.6% respectively.

Example 84

40 To 5 g of DCHA salt of (97) were added and dissolved 50 ml of chloroform and 100 ml of acetonitrile. To the resultant solution were added 2.5 g of Asp(OMe)*HCl, and then gradually 3.2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 1.1 g of monoEG-Mn-DP-diAsp (100). The yield was 27.0%.

45 Example 85

To 3 g of DCHA salt of (97) were added and dissolved 90 ml of chloroform and 45 ml of acetonitrile. To the resultant solution were added 3 g of Phe(OMe)*HCl, and then gradually 3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 2.61 g of monoEG-Mn-DP-diPhe (101). The yield was 100%.

Example 86

55 To 4 g of DCHA salt of (97) were added and dissolved 180 ml of chloroform and 60 ml of acetonitrile. To the resultant solution were added 4 g of Tyr(OMe)*HCl, and then gradually 3.75 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 3.59 g of monoEG-

Mn-DP-diTyr (102). The yield was 100%.

Example 87

To 30 g of Mn-protoporphyrin dimethyl ester (hereinafter referred to as Mn-PP-Me) was added and dissolved 300 ml of 10% HBr/HOAc. After being left standing for 24 hours, the resultant solution was concentrated under reduced pressure, and the Br derivative obtained by concentration was added and dissolved with 150 ml of ethylene glycol, and left standing for another 24 hours. After the reaction was completed (confirmed by TLC), the reaction product was washed with water, hydrolyzed and recrystallized (acetone-ethyl acetate) as in Example 8 to obtain 20 g of EG-Mn-DP (103). The yield was 58.0%.

Example 88

To 2 g of DCHA salt of (103) were added and dissolved 20 ml of chloroform and 40 ml of acetonitrile. To the resultant solution were added 1 g of Gly(OEt)*HCl dissolved in 1 ml of DMF, and then gradually 8 ml of 5% WSC chloroform solution while stirring. The procedure similar to that of Example 23 was thereafter followed to obtain 0.13 g of EG-Mn-DP-monoGly (104). The yield was 8.3%.

Example 89

To 2 g of DCHA salt of (103) were added and dissolved 20 ml of chloroform and 40 ml of acetonitrile. To the resultant solution were added 1 g of Asp(OMe)*HCl dissolved in 1 ml of DMF, and then gradually 3 ml of 5% WSC chloroform solution while stirring. The procedure similar to that of Example 23 was thereafter followed to obtain 0.13 g of EG-Mn-DP-monoAsp (108). The yield was 8.9%.

Example 90

To 5 g each of C₈-DP, C₁₀-DP, C₁₁-DP, C₁₂-DP, C₁₄-DP, C₁₅-DP and C₁₈-DP were added separately and dissolved 30 ml of chloroform and 10 ml of methanol. To the resultant solutions were respectively added 5.1 g of manganese acetate dissolved in 4 ml of methanol, and the products were treated similarly as in Example 82 and Mn ion complexed to obtain respectively 5.71 g, 4.75 g, 4.29 g, 4.58 g, 5.0 g, 5.1 g and 5.5 g of C₈-Mn-DP, C₁₀-Mn-DP, C₁₁-Mn-DP, C₁₂-Mn-DP, C₁₄-Mn-DP, C₁₅-Mn-DP and C₁₈-Mn-DP. The yields were respectively 84.3%, 88.4%, 58.4%, 60.5%, 63.1%, 61.4% and 63.4%.

Example 91

To 20 g of Mn-PP-Me was added and dissolved 200 ml of 10% HBr/HOAc. After being left standing for 24 hours, the resultant solution was concentrated under reduced pressure at 50 °C or below, and the obtained Br derivative was added and dissolved with 100 ml of octanol. The resultant solution was left standing for 24 hours. After the reaction (confirmed by TLC), the reaction product was washed with water, hydrolyzed as in Example 8, and recrystallized (ethyl acetate - hexane) to obtain 15 g of C₈-Mn-DP. The yield was 55.1%.

Example 92

To 2 g of DCHA salt of C₈-Mn-DP obtained in Example 90 were added and dissolved 20 ml of chloroform and 40 ml of acetonitrile. To the resultant solution were added 1 g of Gly(OEt)*HCl dissolved in 1 ml of DMF, and then gradually 2 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.4 g of C₈-Mn-DP-diGly (115). The yield was 25.0%.

Example 93

To 0.7 g of DCHA salt of C₈-Mn-DP were added and dissolved 14 ml of chloroform and 7 ml of methanol. To the resultant solution were added 0.93 g of Asp(OMe)*HCl, and then gradually 1.1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.53 g of C₈-Mn-DP-diAsp (118). The yield was 80.0%.

Example 94

To 0.5 g of DCHA salt of C₁₀-Mn-DP obtained in Example 90 were added and dissolved 11.4 ml of chloroform and 3.8 ml of acetonitrile. To the resultant solution were added 0.6 g of Gly(OEt)*HCl, and then gradually 0.6 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.37 g of C₁₀-Mn-DP-diGly (117). The yield was 96.7%.

Example 95

To 0.9 g of DCHA salt of crude C₁₀-Mn-DP were added and dissolved 18 ml of chloroform and 8 ml of acetonitrile. To the resultant solution were added 1 g of Leu(OMe)*HCl, and then gradually 1.7 g of WSC while stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain respectively 0.36 g and 0.01 g of C₁₀-Mn-DP-diLeu (119) and C_{10(mon)}-Mn-DP-diLeu (129). The yields were respectively 47.4% and 1.2%.

Example 96

To 0.5 g of DCHA salt of C₁₀-Mn-DP were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.3 g of Ser(OMe)*HCl, and then gradually 10 ml of 5% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.34 g of C₁₀-Mn-DP-diSer (120). The yield was 84.9%.

Example 97

To 0.45 g of DCHA salt of C₁₀-Mn-DP were added and dissolved 5 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.59 g of Asp(OMe)*HCl, and then gradually 7 ml of 10% DCC chloroform solution while stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain 0.1 g of C₁₀-Mn-DP-diAsp (122). The yield was 26.2%.

Example 98

To 0.45 g of DCHA salt of C₁₀-Mn-DP were added and dissolved 9 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.59 g of [D]Asp(OMe)*HCl, and then gradually 0.7 g of WSC while cooling and stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain 0.15 g of C₁₀-Mn-DP-di[D]Asp (123). The yield was 39.4%.

Example 99

To 0.2 g of DCHA salt of crude C₁₀-Mn-DP were added and dissolved 4.5 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.29 g of Glu(OEt)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7, 8 and 54 was thereafter followed to obtain respectively 0.06 g and 0.01 g of C₁₀-Mn-DP-diGlu (124) and C_{10(mon)}-Mn-DP-diGlu (130). The yields were respectively 34.6% and 7.8%.

Example 100

To 0.5 g of DCHA salt of C₁₀-Mn-DP were added and dissolved 12 ml of chloroform and 4 ml of acetonitrile. To the resultant solution were added 0.7 g of Phe(OMe)*HCl, and then gradually 0.75 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.44 g of C₁₀-Mn-DP-diPhe (125). The yield was 98.6%.

Example 101

To 0.13 g of DCHA salt of (117) obtained in Example 94 were added and dissolved 3 ml of chloroform and 1 ml of acetonitrile. To the resultant solution were added 0.12 g of Asp(OMe)*HCl, and then gradually 0.18 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.11 g of C₁₀-Mn-DP-diGly-diAsp (128). The yield was 93.2%.

Example 102

To 0.33 g of DCHA salt of (119) obtained in Example 95 were added and dissolved 4 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.34 g of Asp(OMe)*HCl, and then gradually 0.33 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.24 g of C₁₀-Mn-DP-diLeu-diAsp (127). The yield was 79.5%.

Example 103

To 0.32 g of DCHA salt of (125) obtained in Example 100 were added and dissolved 7.5 ml of chloroform and 2.5 ml of acetonitrile. To the resultant solution were added 0.3 g of Asp(OMe)*HCl, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.23 g of C₁₀-Mn-DP-diPhe-diAsp (128). The yield was 78.3%.

Example 104

The procedure similar to those of Examples 17 and 62 was followed using 1 g of PP-Me and 10 ml of 10% HBr/HOAc, and 8 g each of geraniol, citronellol, dihydrocitronellol and menthol respectively instead of ethylene glycol to obtain 2,4-bis(1-geranyloxyethyl)-deuteroporphyrin, 2,4-bis(1-citronellyloxyethyl)-deuteroporphyrin, 2,4-bis(1-dihydrocitronellyloxyethyl)-deuteroporphyrin, and 2,4-bis(1-menthyloxyethyl)-deuteroporphyrin (hereinafter respectively referred to as C₁₀(Geran)-DP, C₁₀(Citro)-DP, C₁₀(H₂Citro)-DP and C₁₀(Menthyl)-DP). Each of the compounds obtained was treated similarly as in Example 90 and Mn ion complexed to respectively obtain 0.88 g, 0.4 g, 0.56 g and 0.08 g of C₁₀(Geran)-Mn-DP (131), C₁₀(Citro)-Mn-DP (133), C₁₀(H₂Citro)-Mn-DP (136), and C₁₀(Menthyl)-Mn-DP (139). The yields were respectively 49.3%, 22.6%, 31.5% and 4.5%.

Example 105

To 0.5 g of DCHA salt of (131) obtained in Example 104 were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.5 g of Asp(OMe)*HCl, and then gradually 0.4 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.4 g of C₁₀(Geran)-Mn-DP-diAsp (132). The yield was 95.2%.

Example 106

To 0.33 g of DCHA salt of crude mixture of (133) obtained in Example 104 were added and dissolved 6.8 ml of chloroform and 3.3 ml of acetonitrile. To the resultant solution were added 0.33 g of Asp(OMe)*HCl, and then gradually 0.27 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.27 g of Asp derivative mixture. The mixture was then passed through octylsilica (C8) high performance liquid chromatograph [eluent: MeOH-H₂O (19:1)], to obtain 0.04 g and

0.12 g of $C_{10}(\text{Citro})$ -Mn-monoAsp (134) and $C_{10}(\text{Citro})$ -Mn-diAsp (135) respectively. The yields were 15.8% and 42.9% respectively.

5 Example 107

To 0.66 g of DCHA salt of crude mixture of (136) obtained in Example 104 were added and dissolved 13.2 ml of chloroform and 6.8 ml of acetonitrile. To the resultant solution were added 0.66 g of Asp(OMe)-HCl, and then gradually 0.54 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.58 g of Asp derivative mixture. The mixture was then passed through octylsilica (C8) high performance liquid chromatograph [eluent: MeOH-H₂O (19:1)], to obtain 0.23 g and 0.04 g of $C_{10\alpha_2}(\text{Citro})$ -Mn-diAsp (137) and $C_{10\alpha_2}(\text{Citro,mono})$ -Mn-diAsp (138) respectively. The yields were 38.3% and 8.2% respectively.

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Example 108

To 0.8 g of DCHA salt of crude C_{12} -Mn-DP obtained in Example 90 were added and dissolved 15 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.8 g of Asp(OMe)-HCl, and then gradually 7 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7, 8 and 108 was thereafter followed to obtain 0.5 g and 0.15 g of C_{12} -Mn-DP-diAsp (143) and $C_{12}(\text{mono})$ -Mn-DP-diAsp (147) respectively. The yields were 73.1% and 25.8% respectively.

25 Example 109

To 0.18 g of DCHA salt of (143) obtained in Example 108 were added and dissolved 4.5 ml of chloroform and 1.5 ml of acetonitrile. To the resultant solution were added 0.38 g of Gly(OEt)-HCl, and then gradually 0.8 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.13 g of C_{12} -Mn-DP-diAsp-tetraGly (145). The yield was 96.5%.

Example 110

To 0.6 g of DCHA salt of C_{14} -Mn-DP obtained in Example 90 were added and dissolved 15 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 2.25 g of Asp(OMe)-HCl, and then gradually 2 g of WSC dissolved in 7 ml of chloroform while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.5 g of C_{14} -Mn-DP-diAsp (149). The yield was 97.0%.

40 Example 111

The procedure similar to Examples 17 and 62 was followed using 5 g of PP-Me and 75 ml of 10% HBr/HOAc, and 30 ml each of farnesol, octadecanol, phytol, tetrahydrofurfuryl alcohol, tetrahydropyran-2-methanol, 3-pyridine-methanol and methionol respectively instead of ethylene glycol to obtain 2,4-bis(1-farnesylloxyethyl)-deuteroporphyryn, 2,4-bis(1-octadecenylloxyethyl)-deuteroporphyryn, 2,4-bis(1-phytyloxyethyl)-deuteroporphyryn, 2,4-bis(1-tetra-furfuryloxyethyl)-deuteroporphyryn, 2,4-bis(1-tetrahydro-2-pyran-methylloxyethyl)-deuteroporphyryn, 2,4-bis(1-nicotinylloxyethyl)-deuteroporphyryn and 2,4-bis(1-(2-methylthiopropylloxyethyl)-deuteroporphyryn (hereinafter referred to as $C_{15}(\text{Farnesyl})$ -DP, $C_{18}(\text{Oleyl})$ -DP, $C_{20}(\text{Phytyl})$ -DP, ${}_{H_4}\text{Fran}$ -DP, ${}_{H_4}\text{Pyran}$ -DP, Nct-DP and Msp-DP respectively). Each of the compounds obtained was treated similarly as in Example 90 and Mn ion complexed to respectively obtain 3.52 g, 0.54 g, 0.3 g, 2.25 g, 2.84 g, 1.7 g and 1.58 g of $C_{15}(\text{Farnesyl})$ -Mn-DP (151), $C_{18}(\text{Oleyl})$ -Mn-DP (155), $C_{20}(\text{Phytyl})$ -Mn-DP (158), ${}_{H_4}\text{Fran}$ -Mn-DP (159), ${}_{H_4}\text{Pyran}$ -Mn-DP (161), Nct-Mn-DP (163) and Msp-Mn-DP (165) respectively. The yields were 35.2%, 5.0%, 2.7%, 28.3%, 34.6%, 21.1% and 19.7% respectively.

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Example 112

To 0.06 g of DCHA salt of C₁₅-Mn-DP obtained in Example 90 were added and dissolved 9 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.5 g of Asp(OMe)*HCl, and then gradually 0.6 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.01 g of C₁₅-Mn-DP-diAsp (153). The yield was 19.3%.

Example 113

To 0.84 g of DCHA salt of C₁₈-Mn-DP obtained in Example 90 were added and dissolved 20 ml of chloroform and 10 ml of acetonitrile. To the resultant solution were added 0.8 g of Asp(OMe)*HCl, and then gradually 0.8 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.63 g of C₁₈-Mn-DP-diAsp. The yield was 86.3%.

To 0.78 g of DCHA salt of C₁₈-Mn-DP-diAsp obtained were added and dissolved 12.4 ml of chloroform and 6.2 ml of acetonitrile. To the resultant solution were added 1 g of Asp(OMe)*HCl, and then gradually 1 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.43 g of C₁₈-Mn-DP-diAsp-tetraAsp (154). The yield was 44.5%.

Example 114

To 0.52 g of DCHA salt of (155) obtained in Example 111 were added and dissolved 10.4 ml of chloroform and 5.2 ml of acetonitrile. To the resultant solution were added 0.52 g of Asp(OMe)*HCl, and then gradually 0.6 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.43 g of C₁₈(OMe)₄-Mn-DP-diAsp (156). The yield was 95.2%.

Example 115

To 0.32 g of DCHA salt of (159) obtained in Example 111 were added and dissolved 6.6 ml of chloroform and 3.3 ml of acetonitrile. To the resultant solution were added 0.33 g of Asp(OMe)*HCl, and then gradually 0.27 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.28 g of H₄Fran-Mn-DP-diAsp (160). The yield was 98.4%.

Example 116

To 0.3 g of DCHA salt of (161) obtained in Example 111 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.3 g of Asp(OMe)*HCl, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.24 g of H₄Pyran-Mn-DP-diAsp (162). The yield was 83.0%.

Example 117

To 0.32 g of DCHA salt of (163) obtained in Example 111 were added and dissolved 6.6 ml of chloroform and 3.3 ml of acetonitrile. To the resultant solution were added 0.33 g of Asp(OMe)*HCl, and then gradually 0.27 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.17 g of Nct-Mn-DP-diAsp (164). The yield was 63.5%.

Example 118

To 0.52 g of DCHA salt of (165) obtained in Example 111 were added and dissolved 10.4 ml of chloroform and 5.2 ml of acetonitrile. To the resultant solution were added 0.52 g of Asp(OMe)*HCl, and then gradually 0.8 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.4 g of Msp-Mn-DP-diAsp (166). The yield was 92.0%.

Example 119

The procedure similar to those of Examples 17 and 62 was followed using 5 g of PP-Me and 75 ml of 10% HBr/HOAc, and 25 ml of octafluoropentyl alcohol instead of ethylene glycol to obtain 1.6 g of 2,4-bis(1-octafluoropentyl)oxyethyl-deuteroporphyrin (hereinafter referred to as $C_{8(F18)}DP$). The resultant compound was treated similarly as in Example 90 and Mn ion complexed to obtain 1.68 g of $C_{8(F18)}Mn-DP$ (167). The yield was 16.7%.

10 Example 120

To 0.3 g of DCHA salt of crude mixture of (167) obtained in Example 119 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.3 g of Gly(OEt)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.27 g of Gly derivative mixture. The mixture was then passed through octylsilica (C8) high performance liquid chromatograph [eluent: MeOH-H₂O (3:1)], to obtain 0.08 g and 0.04 g of $C_{8(F18)}Mn-DP-diGly$ (168) and $C_{8(F8)}Mn-DP-diGly$ (169) respectively. The yields were 33.8% and 20.9% respectively.

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Example 121

To 0.3 g of DCHA salt of crude mixture of (167) obtained in Example 119 were added and dissolved 6 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.3 g of Asp(OMe)*HCl, and then gradually 0.3 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.33 g of Asp derivative mixture. The mixture was then passed through octylsilica (C8) high performance liquid chromatograph [eluent: MeOH-H₂O (3:1)], to obtain 0.1 g and 0.03 g of $C_{8(F18)}Mn-DP-diAsp$ (170) and $C_{8(F8)}Mn-DP-diAsp$ (171) respectively. The yields were 38.6% and 14.0% respectively.

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Example 122

To 0.38 g of DCHA salt of crude mixture of $C_{12}Mn-DP$ obtained in Example 90 were added and dissolved 9 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.21 g of p-trifluoromethylphenylalanine methyl ester hydrochloride (hereinafter referred to as $Phe_{(F3)}(OMe)*HCl$), and then gradually 0.75 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain $Phe_{(F3)}$ derivative mixture. The resultant mixture was passed through octylsilica (C8) high performance liquid chromatograph [eluent: MeOH-H₂O (99:1)], to obtain 0.12 g and 0.01 g of $C_{12}Mn-DP-diPhe_{(F3)}$ (173) and $C_{12(mon)}Mn-DP-diPhe_{(F3)}$ (175) respectively. The yields were 41.5% and 3.0% respectively.

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Example 123

To 0.09 g of DCHA salt of (173) obtained in Example 122 were added and dissolved 2.4 ml of chloroform and 0.8 ml of acetonitrile. To the resultant solution were added 0.12 g of Glu(OEt)*HCl, and then gradually 0.26 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.07 g of $C_{12}Mn-DP-diPhe_{(F3)}-diGlu$ (174). The yield was 82.5%.

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Example 124

To 0.5 g each of C_6-DP and $C_{12}-DP$ obtained in Example 75 was separately added 10 ml of dimethylacetamide, and the resultant mixture was suspended with 1.6 g of ferric chloride 6H₂O, and reacted for 3 hours under heating (100°C). The reaction solution was then concentrated, added with water, and crystals were precipitated. The obtained precipitates were then filtered off, dried and then treated similarly as in Examples 8 and 62 to obtain 0.4 g and 0.14 g of $C_6-Fe-DP$ and $C_{12}-Fe-DP$ respectively. The

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yields were 72.2% and 25.8% respectively.

Example 125

To 0.25 g of DCHA salt of C_8 -Fe-DP obtained in Example 124 were added and dissolved 5 ml of chloroform and 2.5 ml of acetonitrile. To the resultant solution were added 0.25 g of $Asp(OMe)^*HCl$, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.22 g of C_8 -Fe-DP-diAsp (181). The yield was 98.0%.

Example 126

To 0.12 g of DCHA salt of crude mixture of C_{12} -Fe-DP obtained in Example 124 were added and dissolved 4 ml of chloroform and 2 ml of acetonitrile. To the resultant solution were added 0.12 g of $Asp(OMe)^*HCl$, and then gradually 0.27 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.09 g of Asp derivative mixture. The resultant mixture was then passed through octylsilica (C8) high performance liquid chromatograph [eluent: $MeOH-H_2O$ (99:1)], to obtain 0.04 g and 0.005 g of C_{12} -Fe-diAsp (183) and $C_{12(monod)}$ -Fe-diAsp (184) respectively. The yields were respectively 36.7% and 5.6%.

Example 127

To 0.84 g each of C_{10} -DP and C_{12} -DP obtained in Example 75 were added and dissolved respectively 20 ml of chloroform and 10 ml of methanol. The resultant solutions were further added with 1.82 g of cobalt acetate dissolved in 10 ml of methanol and reacted. The reaction solutions were concentrated and added with water, and crystals were precipitated. The obtained precipitates were filtered off, dried and then treated similarly as in Examples 8 and 62 to obtain 0.6 g and 0.53 g of C_{10} -Co-DP and C_{12} -Co-DP respectively. The yields were 82.9% and 77.9% respectively.

Example 128

To 0.3 g of DCHA salt of C_{10} -Co-DP obtained in Example 127 were added and dissolved 15 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.3 g of $Asp(OMe)^*HCl$, and then gradually 0.35 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.26 g of C_{10} -Co-DP-diAsp (185). The yield was 96.4%.

Example 129

To 0.43 g of DCHA salt of C_{12} -Co-DP obtained in Example 127 were added and dissolved 10 ml of chloroform and 5 ml of acetonitrile. To the resultant solution were added 0.43 g of $Asp(OMe)^*HCl$, and then gradually 0.4 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.23 g of C_{12} -Co-DP-diAsp (186). The yield was 59.2%.

Example 130

To 0.3 g of C_{12} -DP obtained in Example 75 were added and dissolved 10 ml of chloroform and 5 ml of methanol. To the resultant solution was added 0.84 g of copper acetate and reacted. The reaction liquid was concentrated, added with water, and crystals were precipitated. The obtained precipitates were filtered off, dried and then treated similarly as in Examples 8 and 62 to obtain 0.31 g of C_{12} -Cu-DP. The yield was 97.0%.

Example 131

To 0.4 g of DCHA salt of C_{12} -Cu-DP obtained in Example 130 were added and dissolved 10 ml of chloroform and 3 ml of acetonitrile. To the resultant solution were added 0.4 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.4 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.3 g of C_{12} -Cu-DP-diAsp (181). The yield was 83.0%.

Example 132

To 0.5 g each of EG-DP and C_{12} -DP obtained in Example 75 were respectively added and dissolved 15 ml of chloroform and 2.5 ml of methanol. The resultant solutions were added with 2.2 ml of 5% zinc acetate methanol solution and reacted. The reaction liquids were concentrated and added with water, and crystals were precipitated. The obtained precipitates were filtered off, dried and then treated similarly as in Examples 8 and 82 to obtain 0.41 g and 0.5 g of EG-Zn-DP (193) and C_{12} -Zn-DP respectively. The yields were 74.5% and 93.7% respectively.

Example 133

To 0.5 g of DCHA salt of (193) obtained in Example 132 were added and dissolved 22 ml of chloroform and 8 ml of acetonitrile. To the resultant solution were added 0.5 g of $\text{Tyr(OMe)}^*\text{HCl}$, and then gradually 7 ml of 10% WSC chloroform solution while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.12 g of EG-Zn-DP-diTyr (194). The yield was 24.7%.

Example 134

To 0.25 g of DCHA salt of C_{12} -Zn-DP obtained in Example 132 were added and dissolved 5 ml of chloroform and 2.5 ml of acetonitrile. To the resultant solution were added 0.25 g of $\text{Asp(OMe)}^*\text{HCl}$, and then gradually 0.25 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.21 g of C_{12} -Zn-DP-diAsp (197). The yield was 92.9%.

Example 135

To 5 g of EG-DP obtained in Example 75 was added 100 ml of DMF. The resultant solution was suspended with 10 g of indium chloride, and reacted for 0.5 hour under heating (120°C). The reaction liquid was concentrated and added with water, and crystals were precipitated. The obtained precipitates were filtered off, dried and then hydrolyzed similarly as in Example 8 to obtain 5.4 g EG-In-DP (199). The yield was 88.9%.

Example 136

To 0.5 g of DCHA salt of (199) obtained in Example 135 was added and dissolved 30 ml of chloroform. To the resultant solution were added 0.5 g of $\text{Tyr(OMe)}^*\text{HCl}$, and then gradually 0.6 g of WSC while stirring. The procedure similar to those of Examples 7 and 8 was thereafter followed to obtain 0.12 g of EG-In-DP-diTyr (200). The yield was 24.6%.

The porphyrin derivatives according to the present invention have the properties to accumulate in tumor cells, to react to external energy, and to destroy tumor cells. Since they do not manifest toxicity in normal cells, they are most useful as a therapeutic agent or a diagnostic agent for cancer.

Fig. 1 is a photograph showing hemorrhagic necrosis of a cancer mass at 24 hours after administration of C_n -Ga-DP-diAsp ($n = \text{odd numbers, 44, 49, 53, 55 and 66}$), and

Fig. 2 is also a photograph showing hemorrhagic necrosis of a cancer mass at 24 hours after administration of C_n -Ga-DP-diAsp ($n = \text{even numbers, 48, 51, 54, 58, 68 and 77}$).

Fig. 3 is also a photograph showing hemorrhagic necrosis of cancer masses at 24 hours after administration of C_{10} -Mn-DP-PheAsp (128) on the right, $C_{10}(\text{Gara})^*\text{Mn-DP-diAsp}$ (132) at the enter, and Ca-Fe-DP-diAsp (181) on the left.

Fig. 4 is a photograph showing necrotic tumor cells of the group administered C_{12} -Mn-DP-diAsp

(143).

Fig. 5 is a photograph of tumor cells of the control group.

Fig. 6 is a graph showing tumor cell growth curves after administrations of the following substances.

○ : Control group

● : C₁₀-Mn-DP-diAsp (122)

■ : C₁₂-Mn-DP-diAsp (143)

Fig. 7 is a graph showing cell growth inhibitions after administrations of the following substances.

▲ : C₈-Ga-DP-diAsp (58) without irradiation

△ : C₈-Ga-DP-diAsp (58) with irradiation

● : C₁₀-Mn-DP-diAsp (122) without irradiation

○ : C₁₀-Mn-DP-diAsp (122) with irradiation

■ : Photofrin II without irradiation

□ : Photofrin II with irradiation

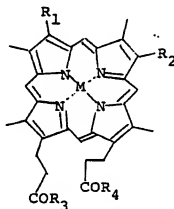
Fig. 8 is a photograph showing an animal given Yag laser irradiation at 24 hours following administration of C₈-Ga-DP-diAsp (54).

Fig. 9 is a photograph showing an animal of the control group given Yag laser irradiation.

Fig. 10 through 19 are graphs showing mass spectra (SIMS-NOBA); Fig. 10 of methyl ester of EG-Ga-DP-monoSer (19), Fig. 11 EG-Ga-DP-monoAsp (22), Fig. 12 methyl ester of C₈-Ga-DP-diSer (57), Fig. 13 methyl ester of C₈-Ga-DP-diAsp (58), Fig. 14 (58), Fig. 15 methyl ester of C₈(mono)-Ga-DP-diAsp (62), Fig. 16 C₈-Mn-DP-diAsp (116), Fig. 17 C₁₀-Mn-DP-diAsp (122), Fig. 18 C₈-Ga-DP, and Fig. 19 ethyl ester of monoEG-Cu-DP-diGly. Figs. 20 through 24 are graphs showing NMR spectra (¹H-NMR); Fig. 20 C₄-Ga-DP-diAsp (51), Fig. 21 C₆-Ga-DP-diAsp (54), Fig. 22 C₈-Ga-DP-diAsp (58), Fig. 23 C₁₀(H₂Citro)-Ga-DP-diAsp (74), and Fig. 24 H₄Fran-Ga-DP-diAsp (80).

Claims

1. Metalloporphyrin compounds represented by the general formula (I)



wherein

R₁ and R₂ are each -CH=CH₂, -CH(OR)₂CH₃ or -CH(O-lower alkylene-OR)₂CH₃;

R₃ and R₄ are -OH or a residue obtained by removing a hydrogen atom from a polyfunctional compound;

R is -H, alkyl, alkenyl, perfluoroalkyl, a cyclic compound, or a residue obtained by removing a hydrogen atom from a polyfunctional compound; and

M is a metal.

2. A metalloporphyrin compound of the general formula (I) according to claim 1 for use as a therapeutic or diagnostic agent for malignant tumors, as a tumor marker or as an agent for use in the missile therapy of cancers.



Fig. 1



Fig. 2



Fig. 3



Fig. 4



Fig. 5

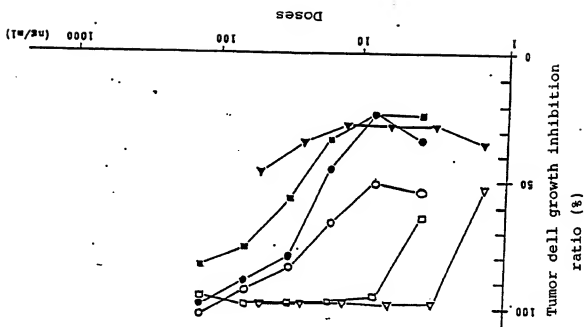


Fig. 7

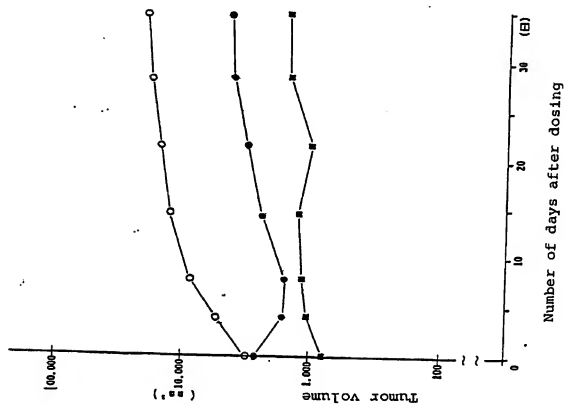


Fig. 6

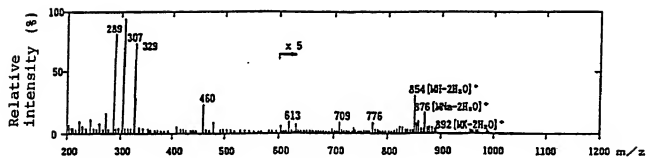


Fig. 10

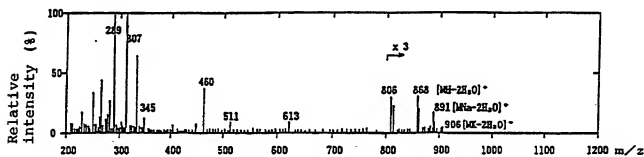


Fig. 11



Fig. 8



Fig. 9

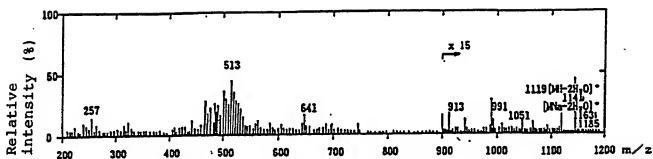


Fig. 14

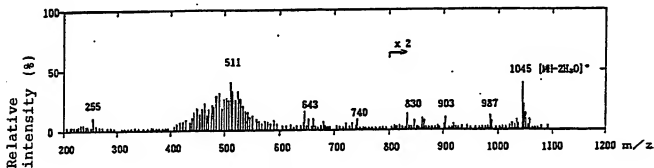


Fig. 15

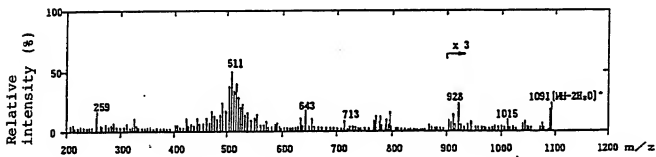


Fig. 12

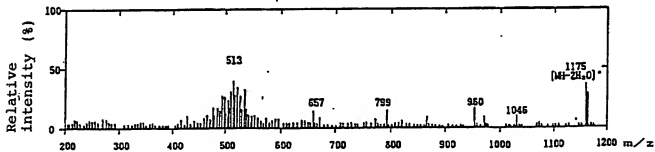


Fig. 13

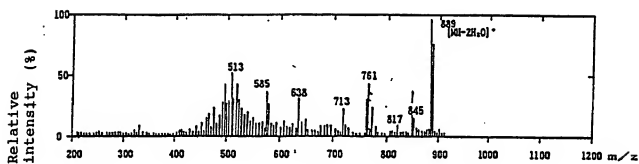


Fig. 18

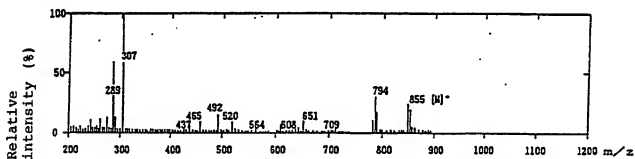


Fig. 19

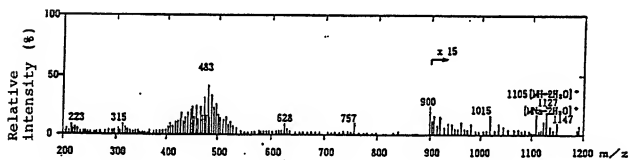


Fig. 16

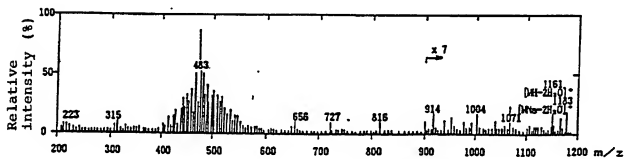


Fig. 17

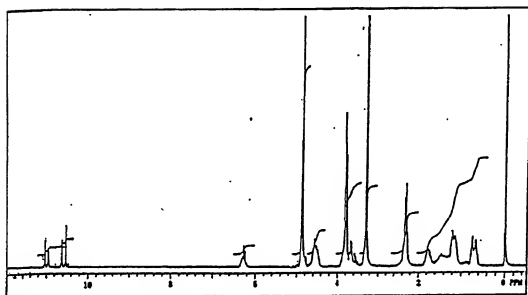


Fig. 21

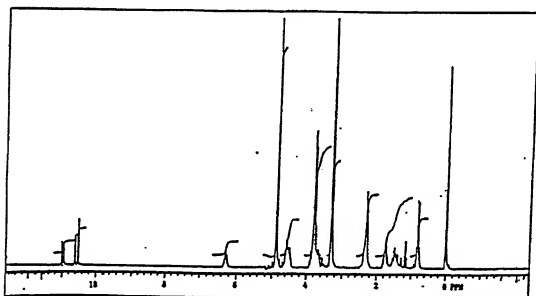


Fig. 20

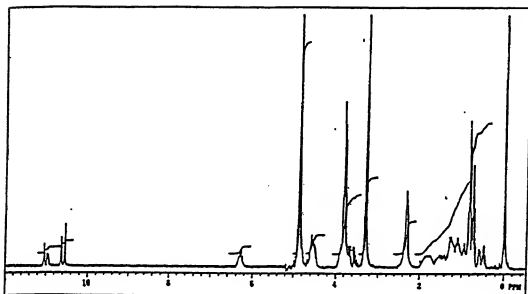


Fig. 23

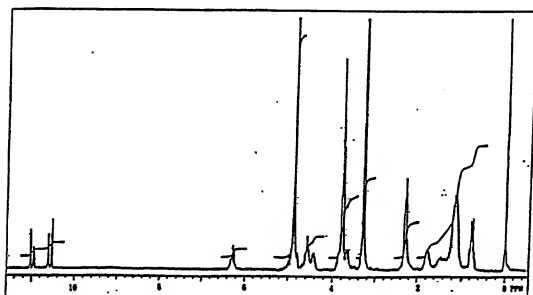


Fig. 22

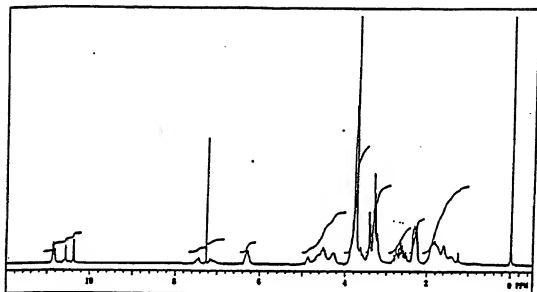


Fig. 24

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